

Mapping of Tropical Cyclone Precipitation Before and After Landfall

Research Partners

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Instrumentation

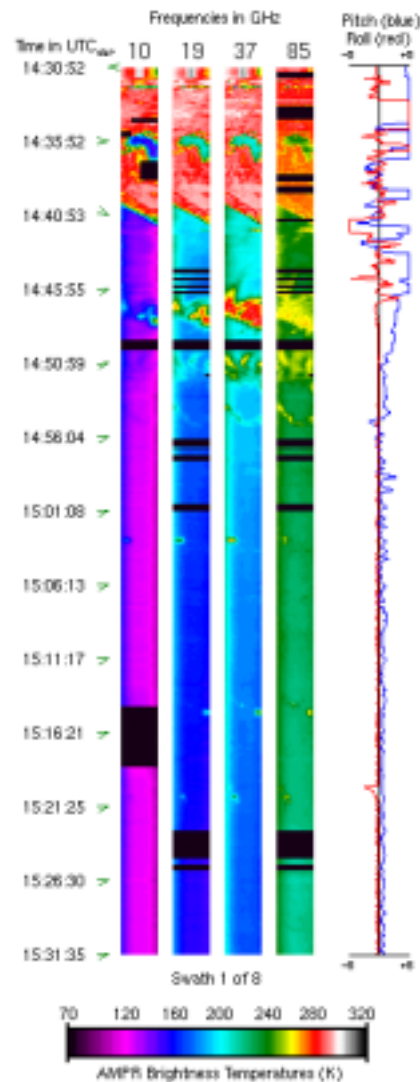
- *Advanced Microwave Precipitation Radiometer (AMPR)*
 - Flown on ER-2 during CAMEX-3 and CAMEX-4
 - 10.7, 19.35, 37.1, 85.5 GHz frequencies
 - Cross-track scanner
 - Rotating polarization (H on left, equal at nadir, V on right)
 - In-flight calibration
 - Designed to study precipitation structures and support TRMM validation
- *Conically-Scanning Two look Airborne Radiometer (C-STAR)*
 - Flown on DC-8 during CAMEX-4
 - 37.1 GHz frequency
 - Conical scanner
 - 53° incidence angle
 - Four polarizations (H, V, V+45°, V-45°)
 - Two look (fore and aft)
 - In-flight calibration
 - Designed to test feasibility of passive ocean wind retrievals

Data Status

- C-STAR performed well during all missions
- AMPR experienced electrical interference problems on ER-2 causing instrument malfunction on early few CAMEX missions. Instrument performance greatly improved after 9 September, but 85 GHz Tb's appear to be lower than expected
- Data have been quality-controlled to eliminate erroneous navigation, calibration, and data values
- Calibration checks have been performed using dropsonde profiles with radiative transfer models
- Have delivered browse images and data for both AMPR and C-STAR to the CAMEX Data Archive

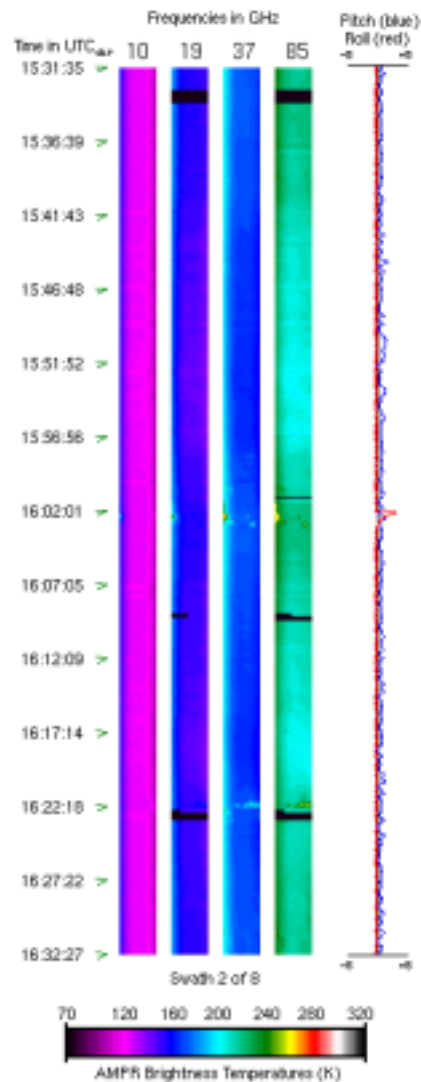
AMPR Swath TBs from CAMEX-4

NASA ER-2 809 Flight 137 on 10 Sep 2001



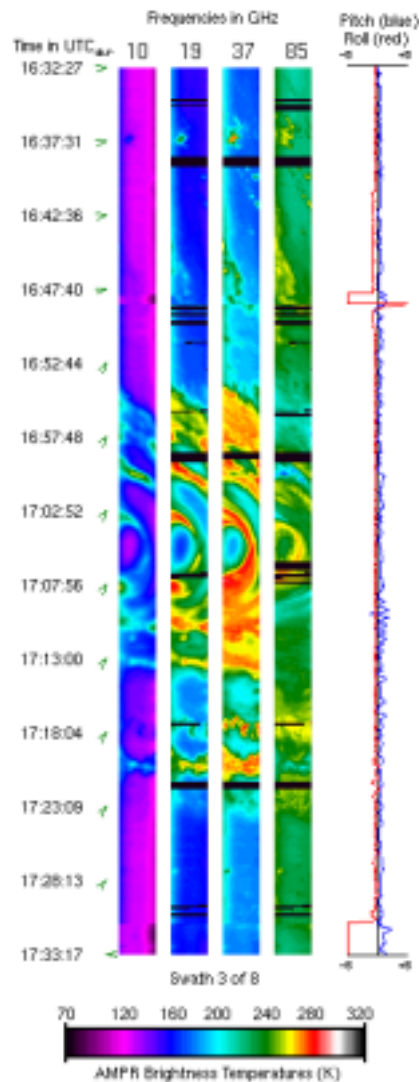
AMPR Swath TBs from CAMEX-4

NASA ER-2 809 Flight 137 on 10 Sep 2001



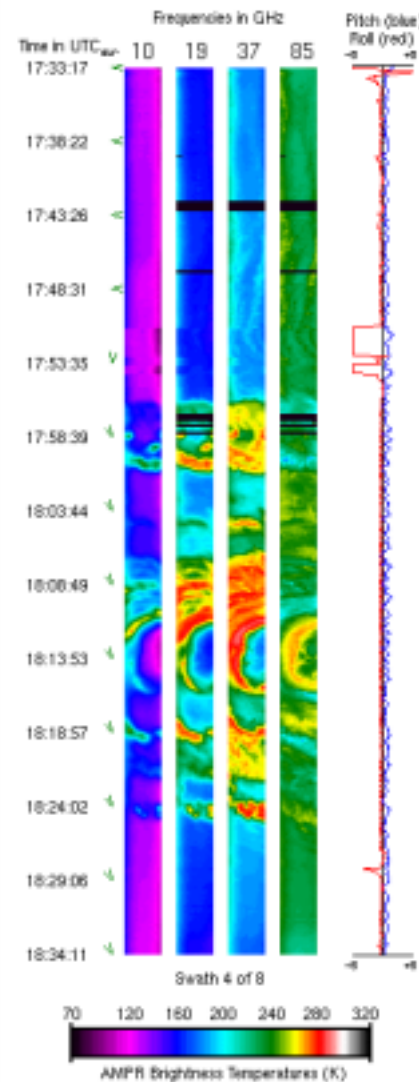
AMPR Swath TBs from CAMEX-4

NASA ER-2 809 Flight 137 on 10 Sep 2001



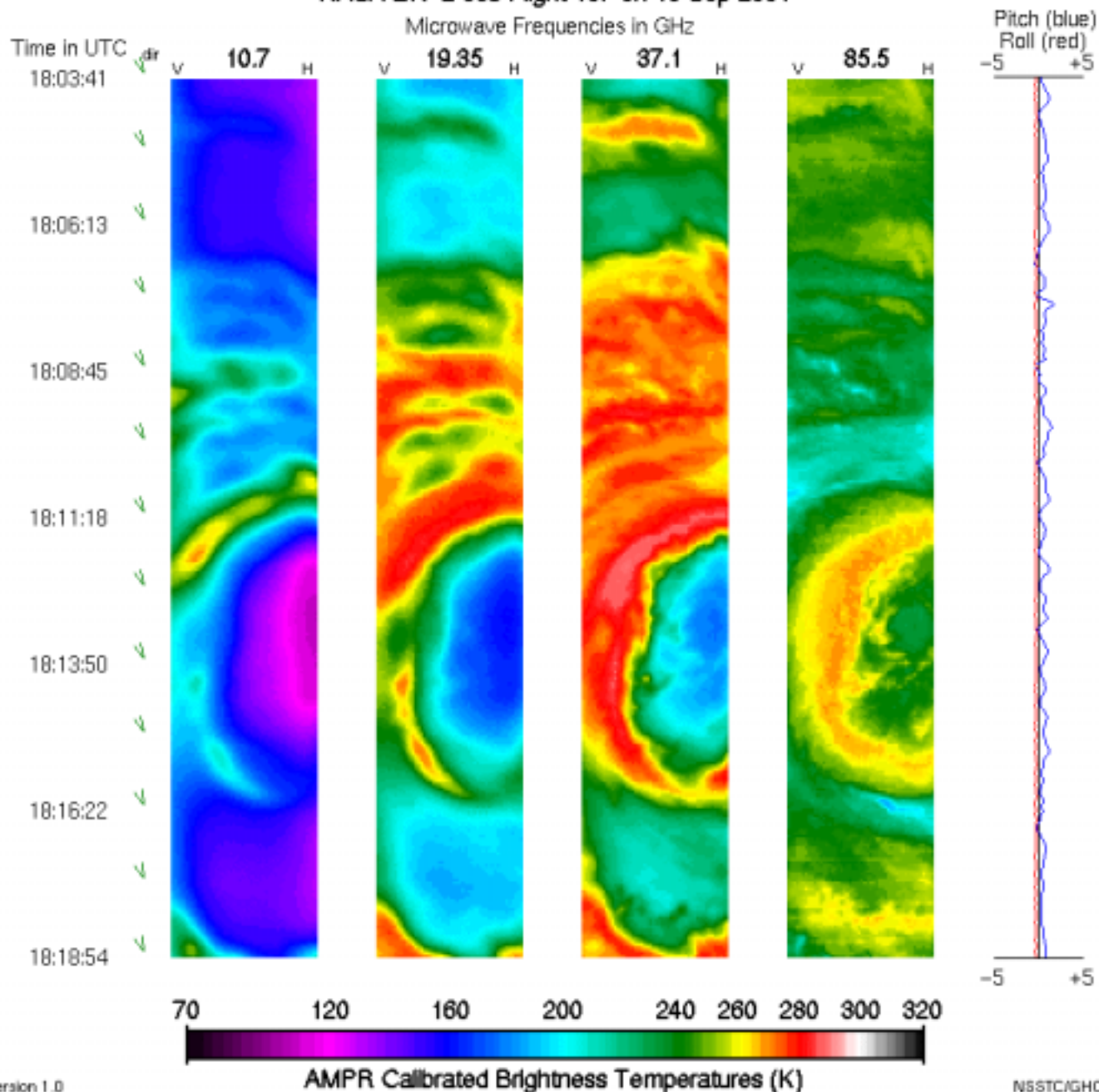
AMPR Swath TBs from CAMEX-4

NASA ER-2 809 Flight 137 on 10 Sep 2001



AMPR BROWSE SWATH TB DATA FROM CAMEX-4

NASA ER-2 809 Flight 137 on 10 Sep 2001



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4

10 Sep 2001 (253) 16:50:15-17:29:11 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$$

Grid Center: 35.70°N x 65.20°W

Grid Resolution: 0.83 km

NASA/NSSTC/GHCC

Some data may have been interpolated

**** PRELIMINARY ****

Elevation in Meters

0 500 1000

Source: United States Geological Survey
Digital Elevation Model (DEM)

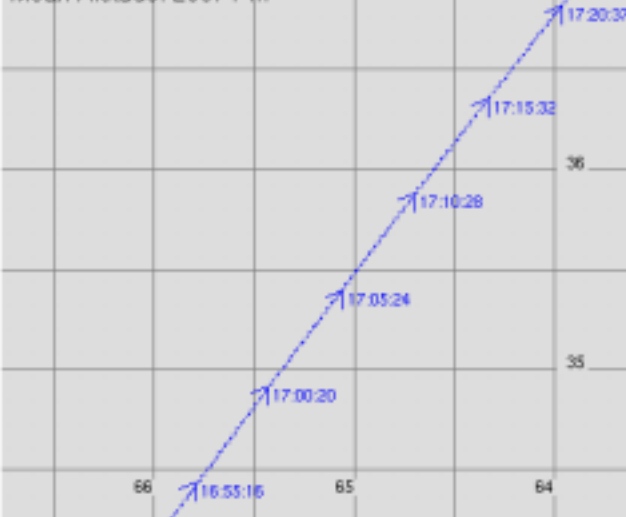
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

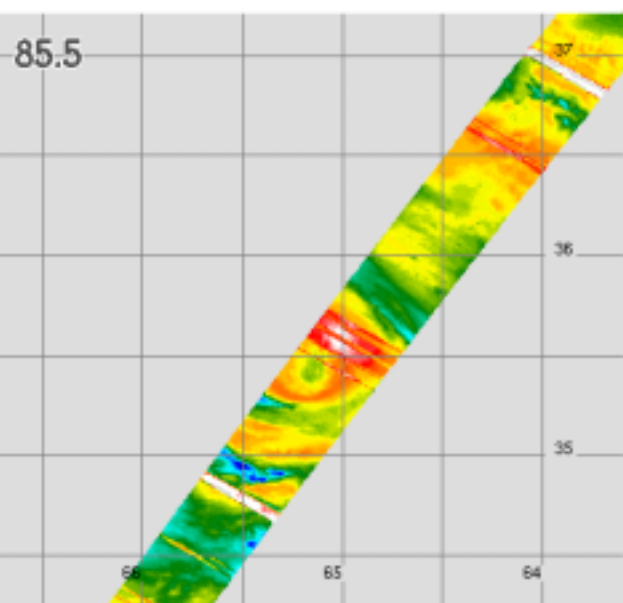
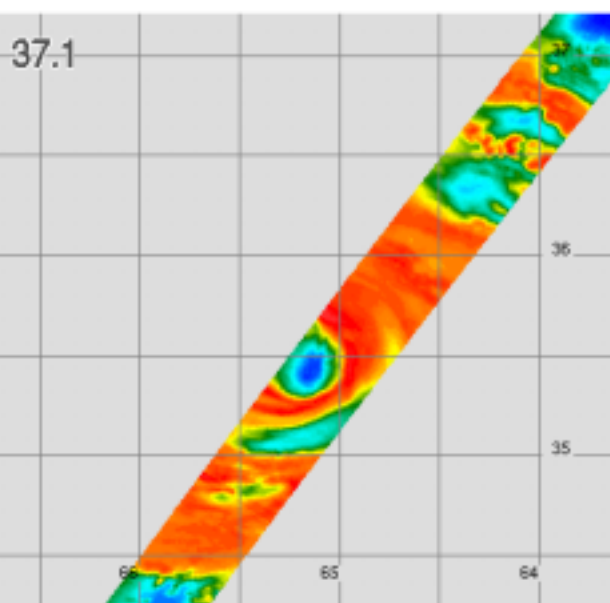
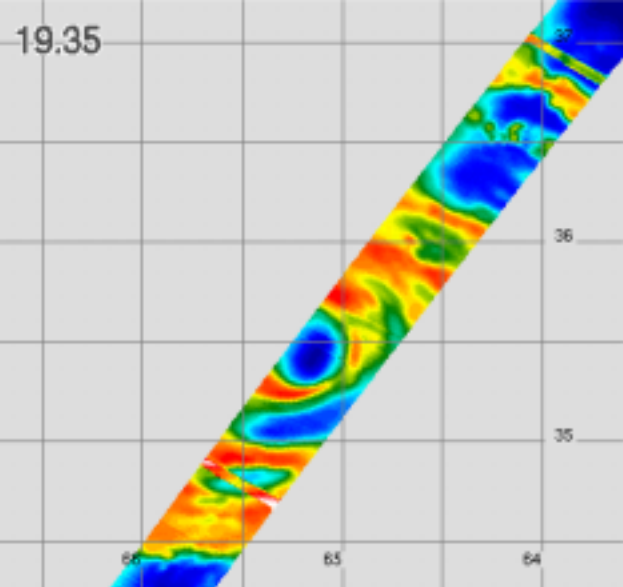
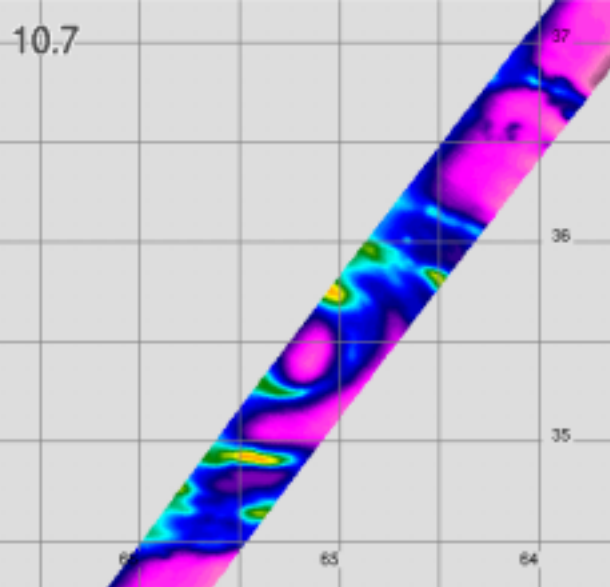


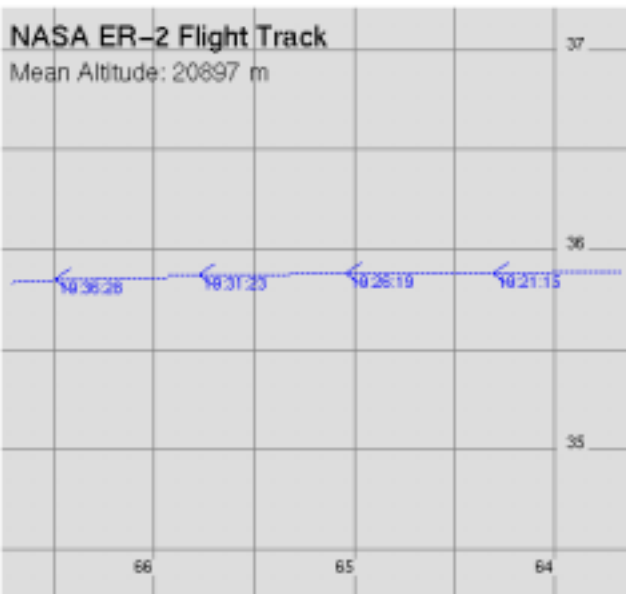
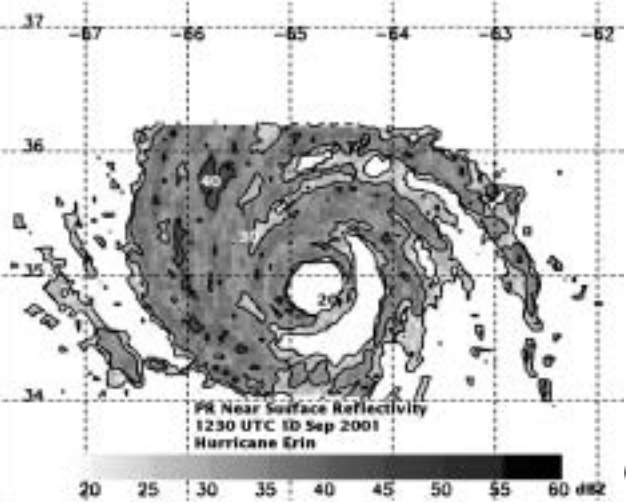
NASA ER-2 Flight Track

Mean Altitude: 20371 m

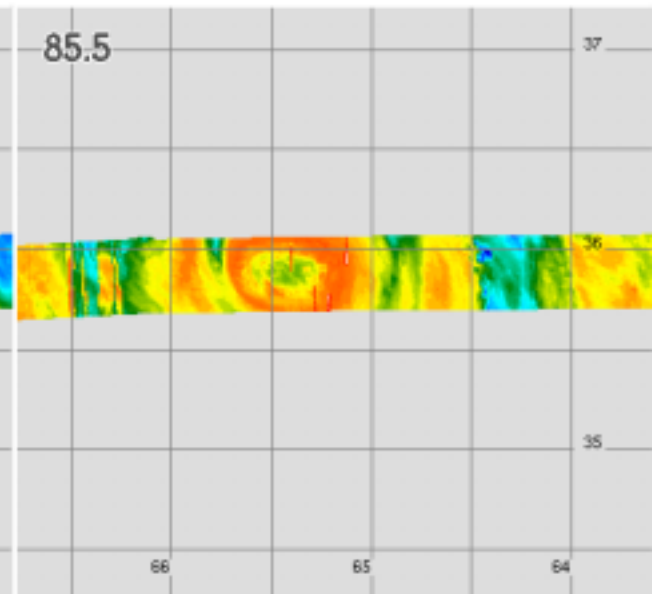
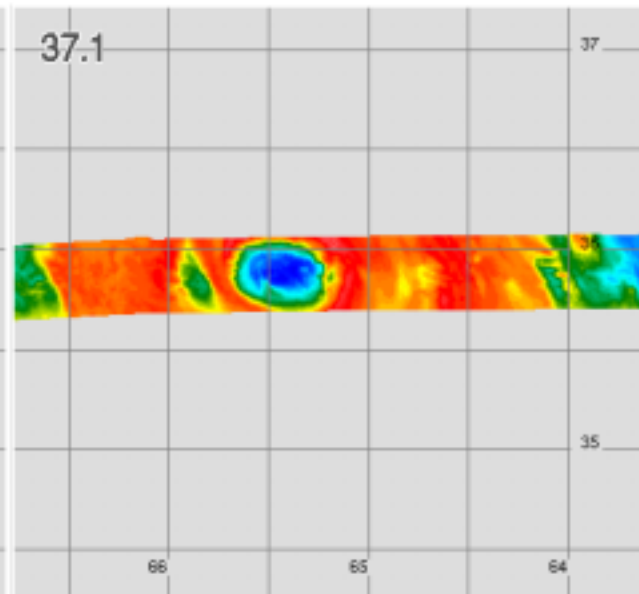
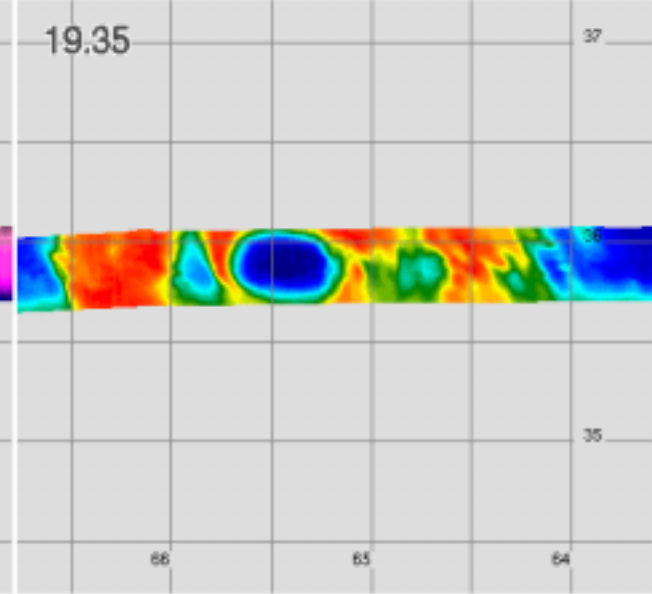
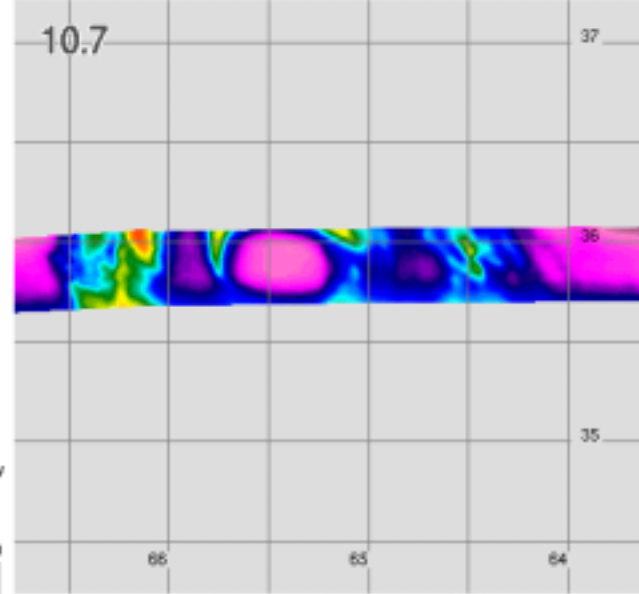


McIDAS based





McIDAS based



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4

10 Sep 2001 (253) 17:56:16-18:32:06 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$$

Grid Center: 35.70°N x 65.20°W

Grid Resolution: 0.83 km

NASA/NSSTC/GHCC

Some data may have been interpolated

**** PRELIMINARY ****

Elevation in Meters

0 500 1000

Source: United States Geological Survey
Digital Elevation Model (DEM)

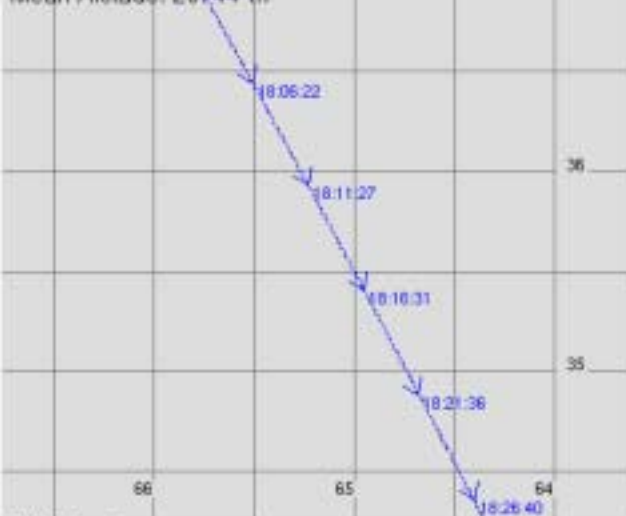
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

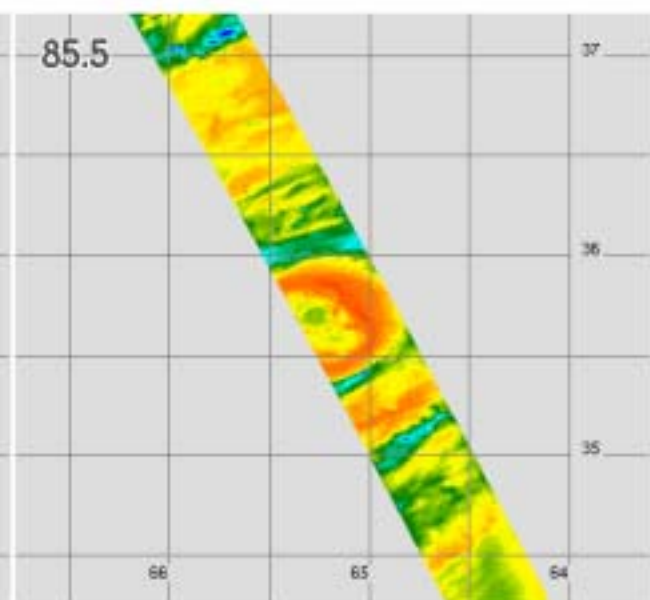
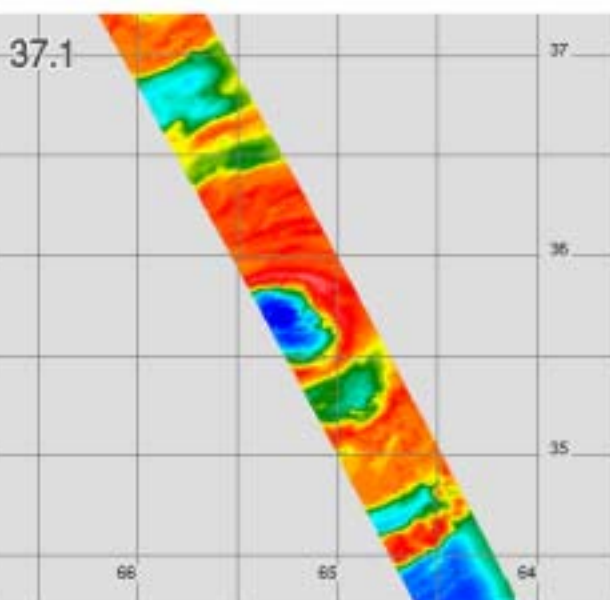
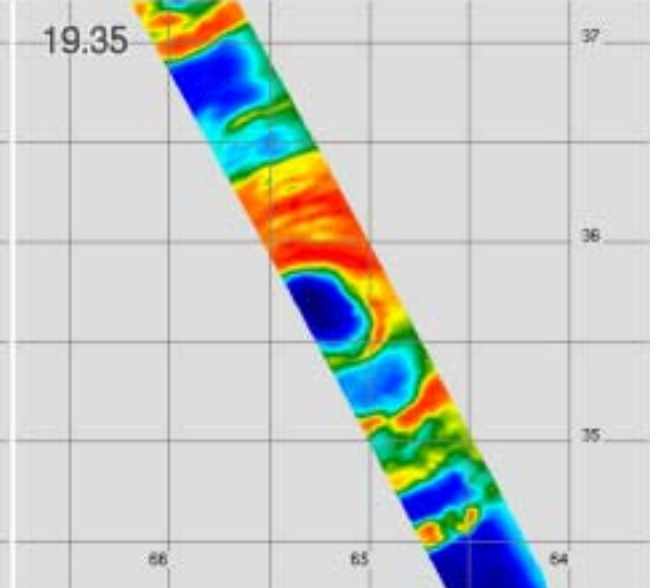
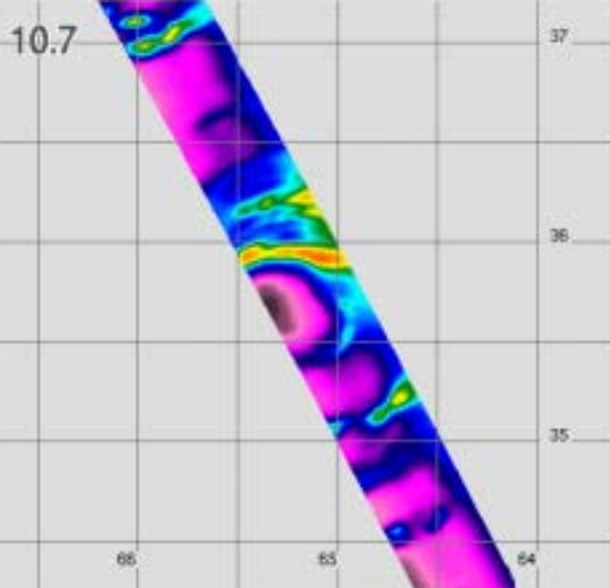


NASA ER-2 Flight Track

Mean Altitude: 20704 m



McIDAS based



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "Erin Composite"

10 Sep 2001 (253) 16:48:59–19:50:30 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$

Grid Center: 35.81°N x 64.63°W

Grid Resolution: 2.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

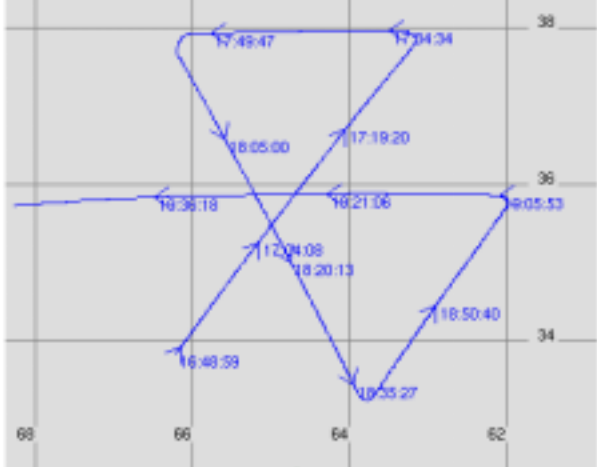


Brightness Temperature in Kelvin

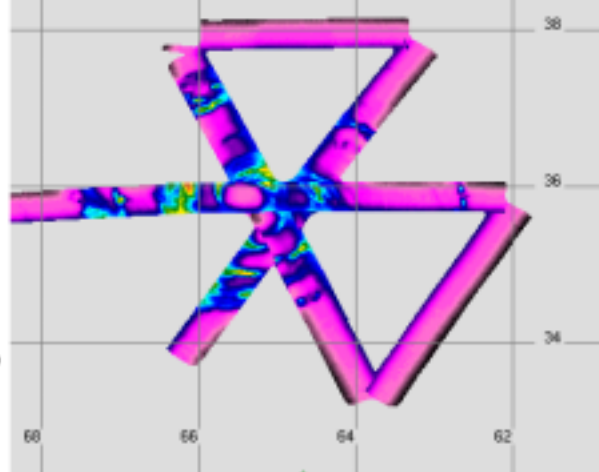


NASA ER-2 Flight Track

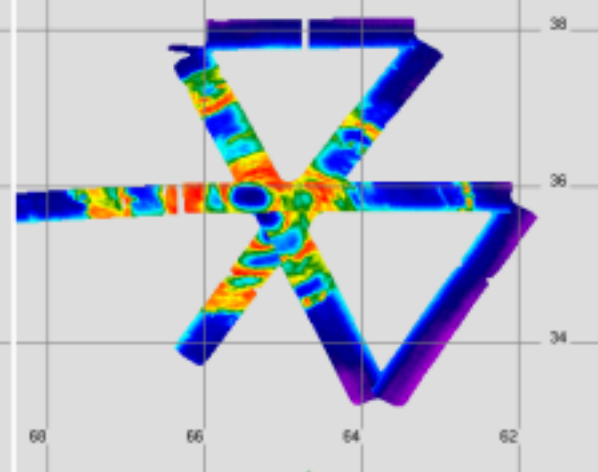
Mean Altitude: 20678 m



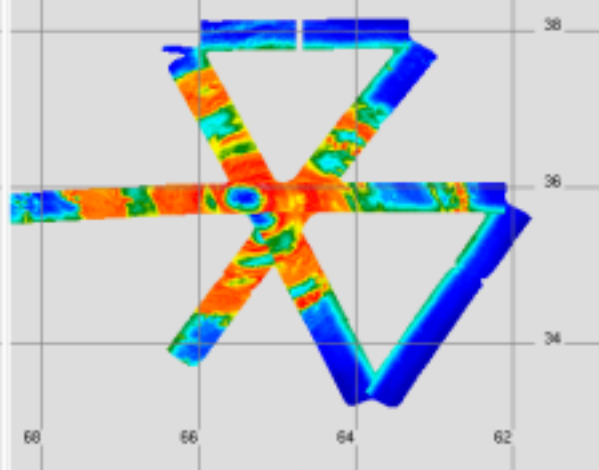
10.7



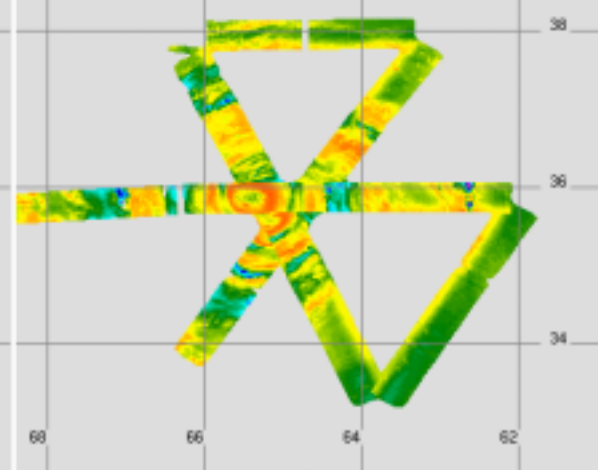
19.35



37.1



85.5



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "T.S. Humberto"

22 Sep 2001 (265) 17:42:44-21:29:45 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$$

Grid Center: 29.00°N x 67.00°W

Grid Resolution: 1.50 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey Digital Elevation Model (DEM)

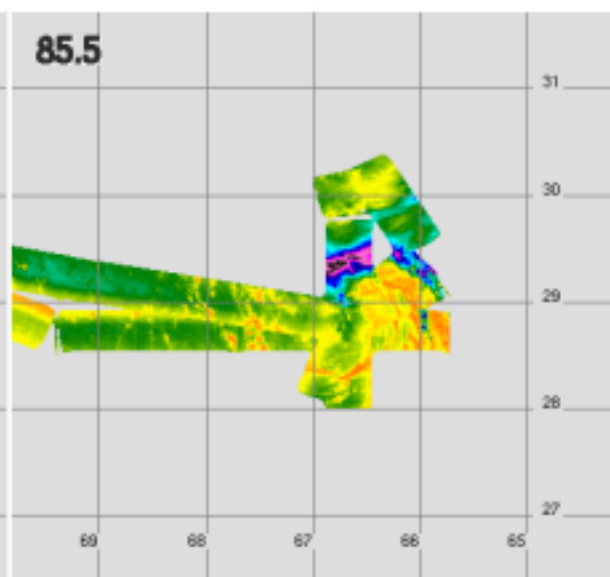
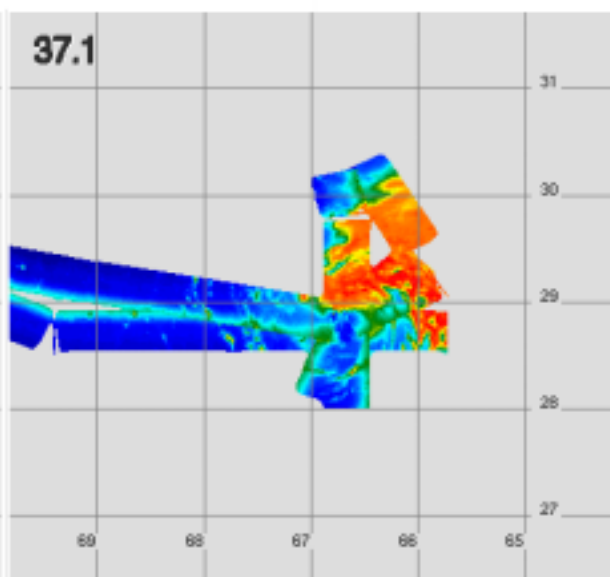
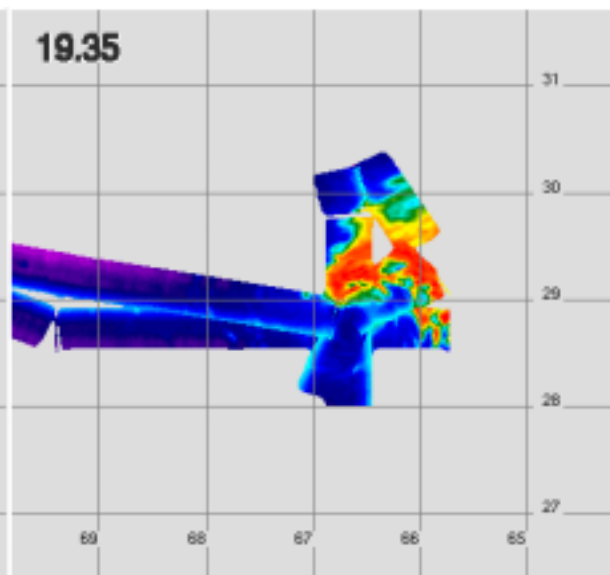
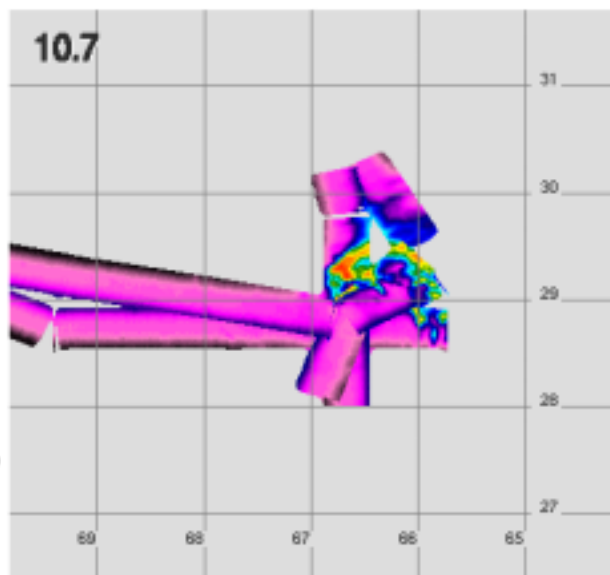
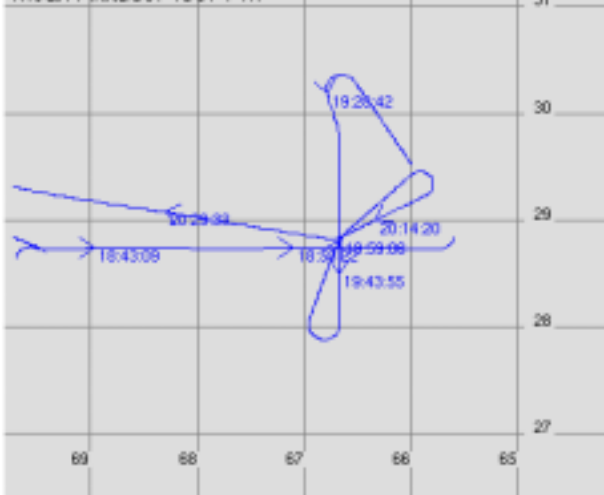
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300



NASA ER-2 Flight Track

Mean Altitude: 19671 m



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4

22 Sep 2001 (265) 19:30:44–19:47:43 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$

Grid Center: 29.00°N x 66.50°W

Grid Resolution: 0.83 km

NASA/NSSTC/GHCC

**** PRELIMINARY ****

Some data may have been interpolated

Elevation in Meters

0 500 1000

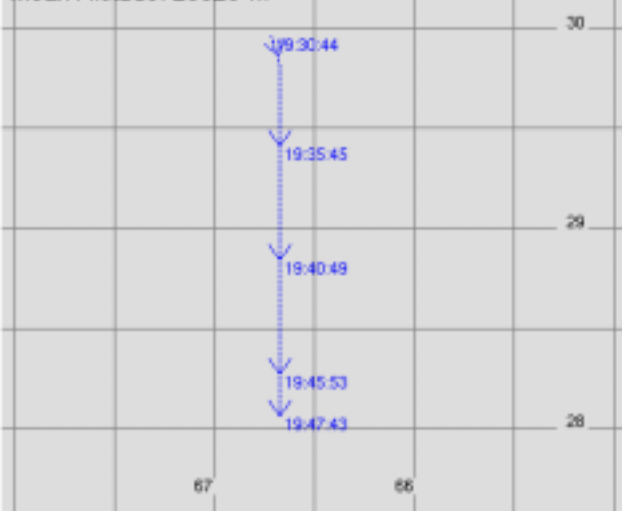
Source: United States Geological Survey
Digital Elevation Model (DEM)

Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

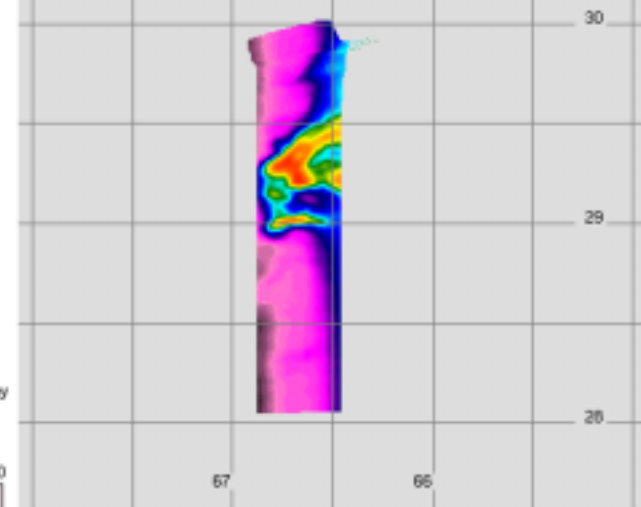
NASA ER-2 Flight Track

Mean Altitude: 20828 m

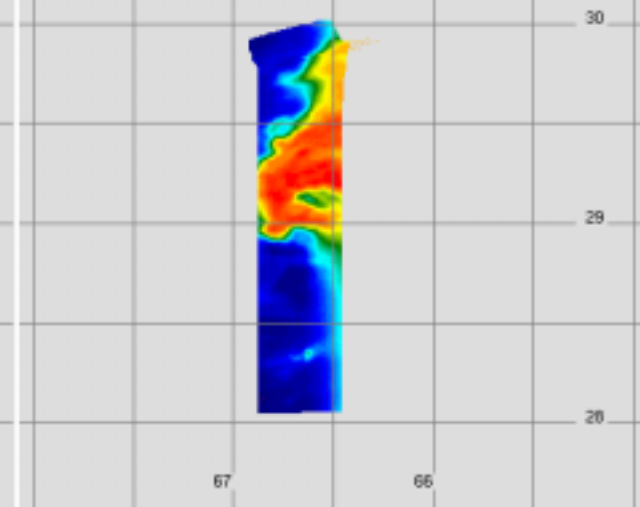


McIDAS based

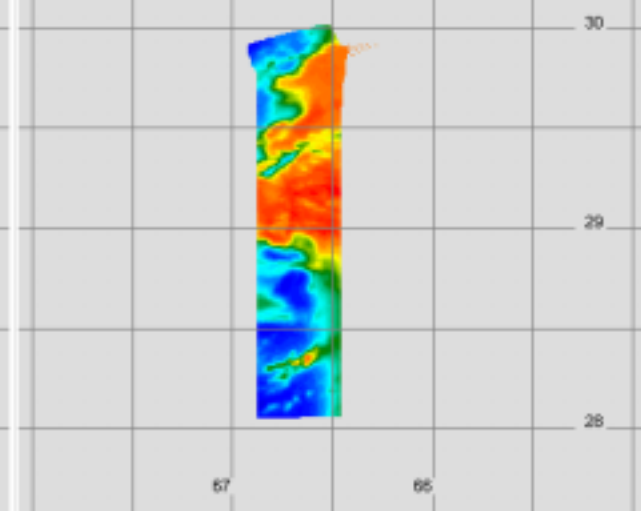
10.7



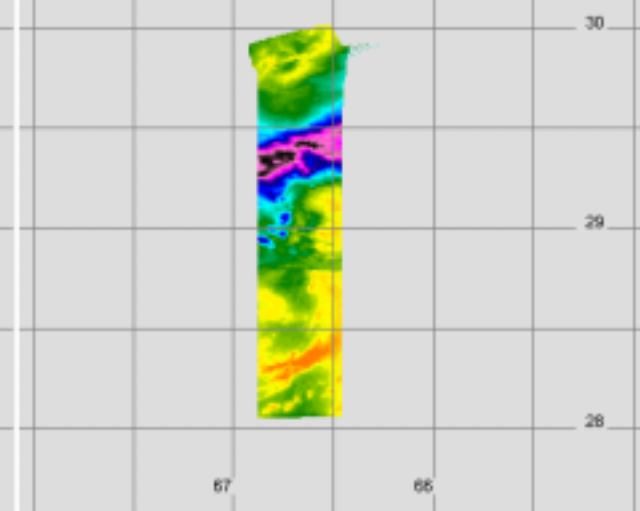
19.35



37.1



85.5



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4

23 Sep 2001 (266) 20:15:55-20:56:20 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$

Grid Center: 32.50°N x 67.20°W

Grid Resolution: 0.89 km

NASA/NSSTC/GHCC

**** PRELIMINARY ****

Some data may have been interpolated

Elevation in Meters

0 500 1000

Source: United States Geological Survey
Digital Elevation Model (DEM)

Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300



NASA ER-2 Flight Track

Mean Altitude: 20330 m

20:46:18

20:41:14

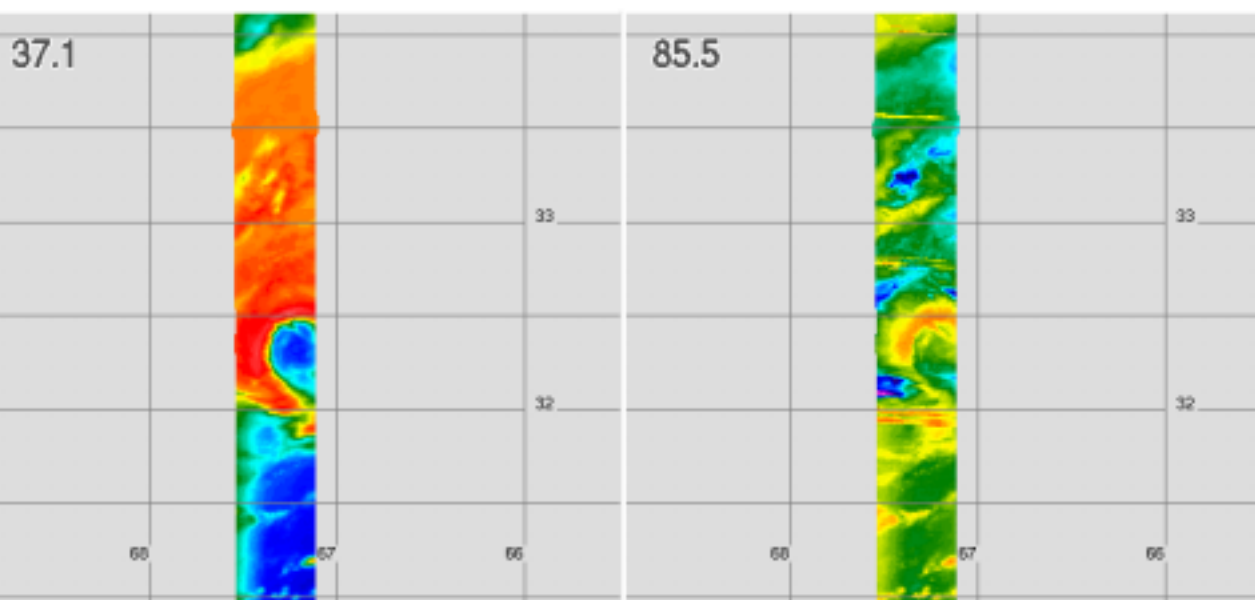
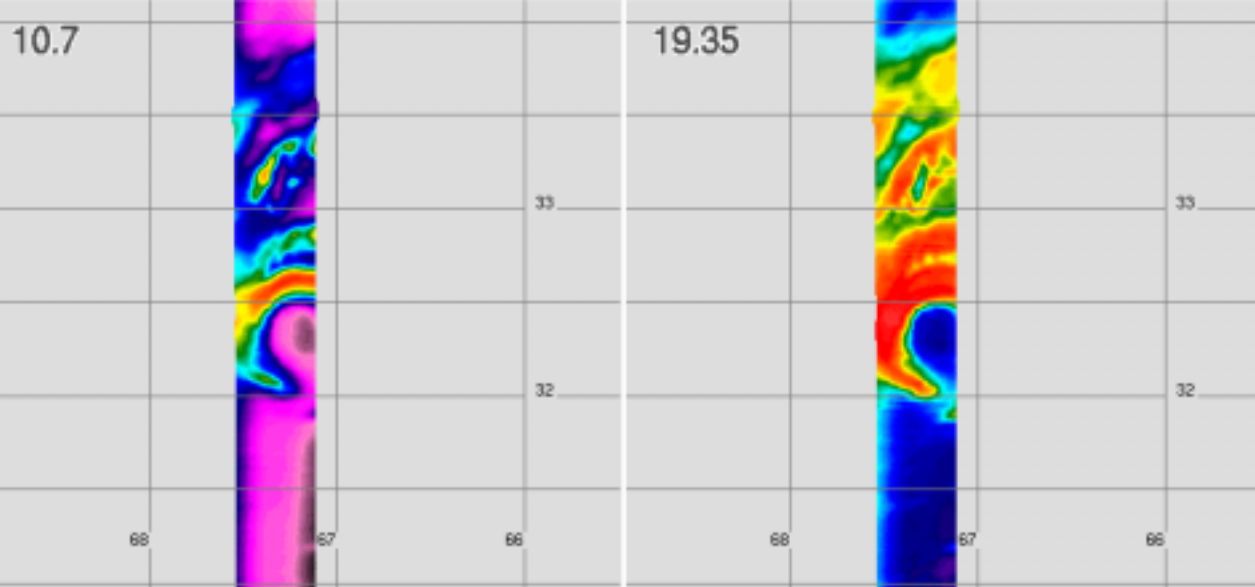
20:36:09

20:31:05

20:26:01

20:20:56

McIDAS based



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "Humberto Eye Pass"

24 Sep 2001 (267) 20:45:48-21:54:22 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$

Grid Center: 36.00°N x 66.50°W

Grid Resolution: 2.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

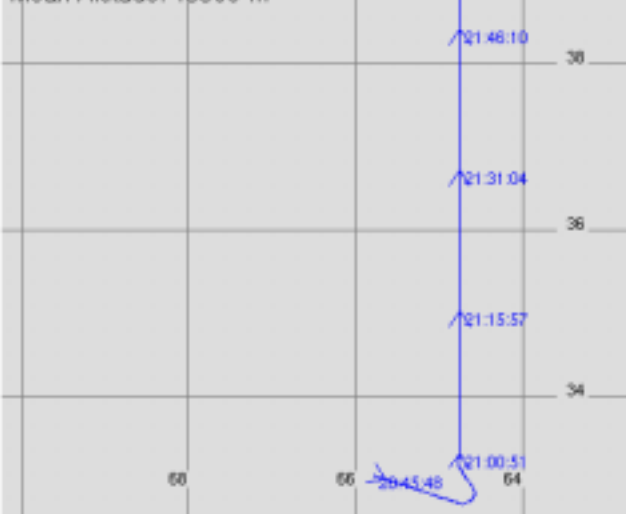
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

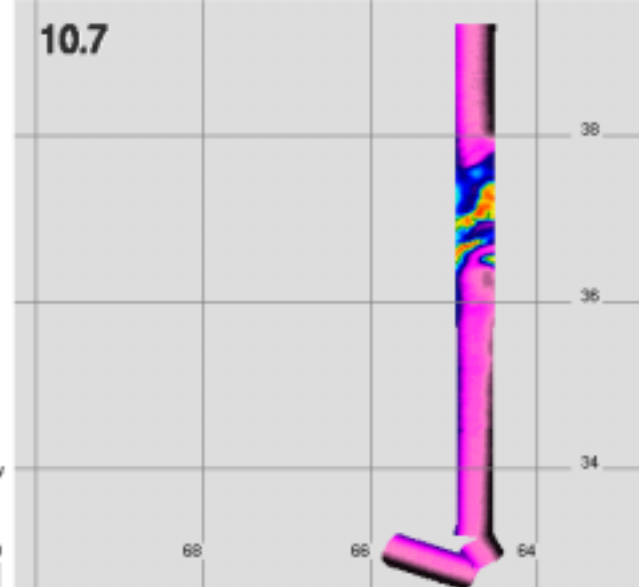


NASA ER-2 Flight Track

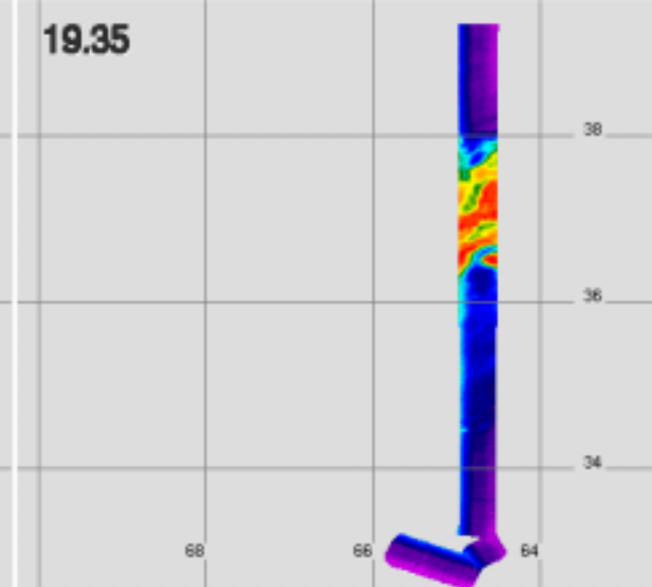
Mean Altitude: 19906 m



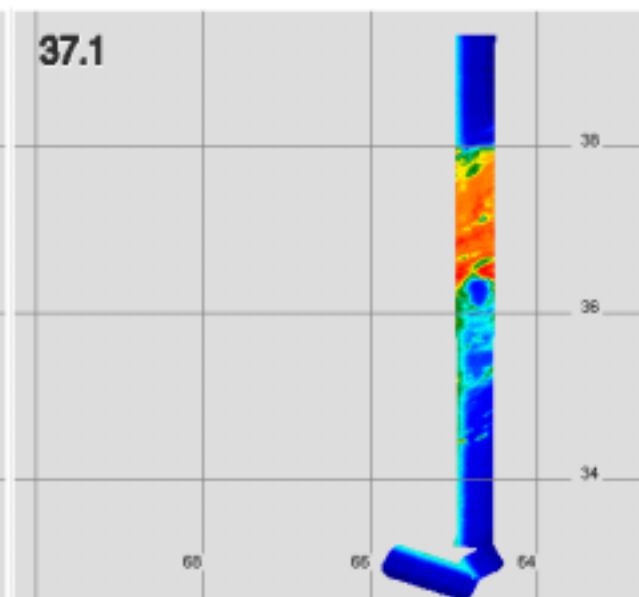
10.7



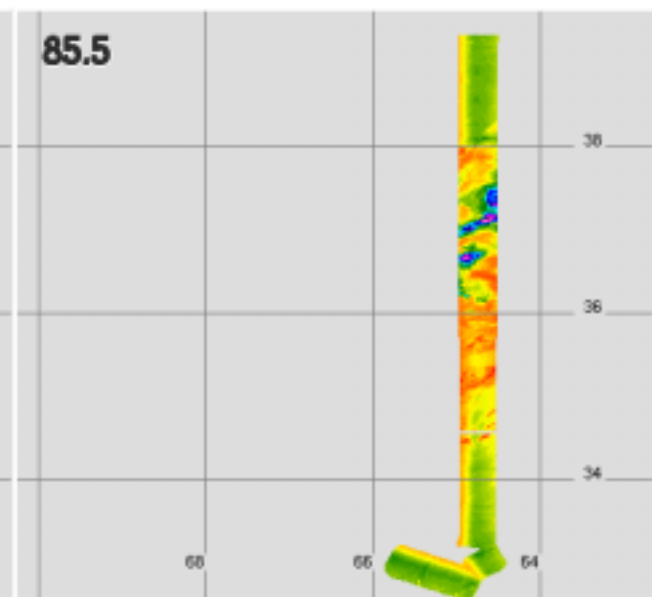
19.35

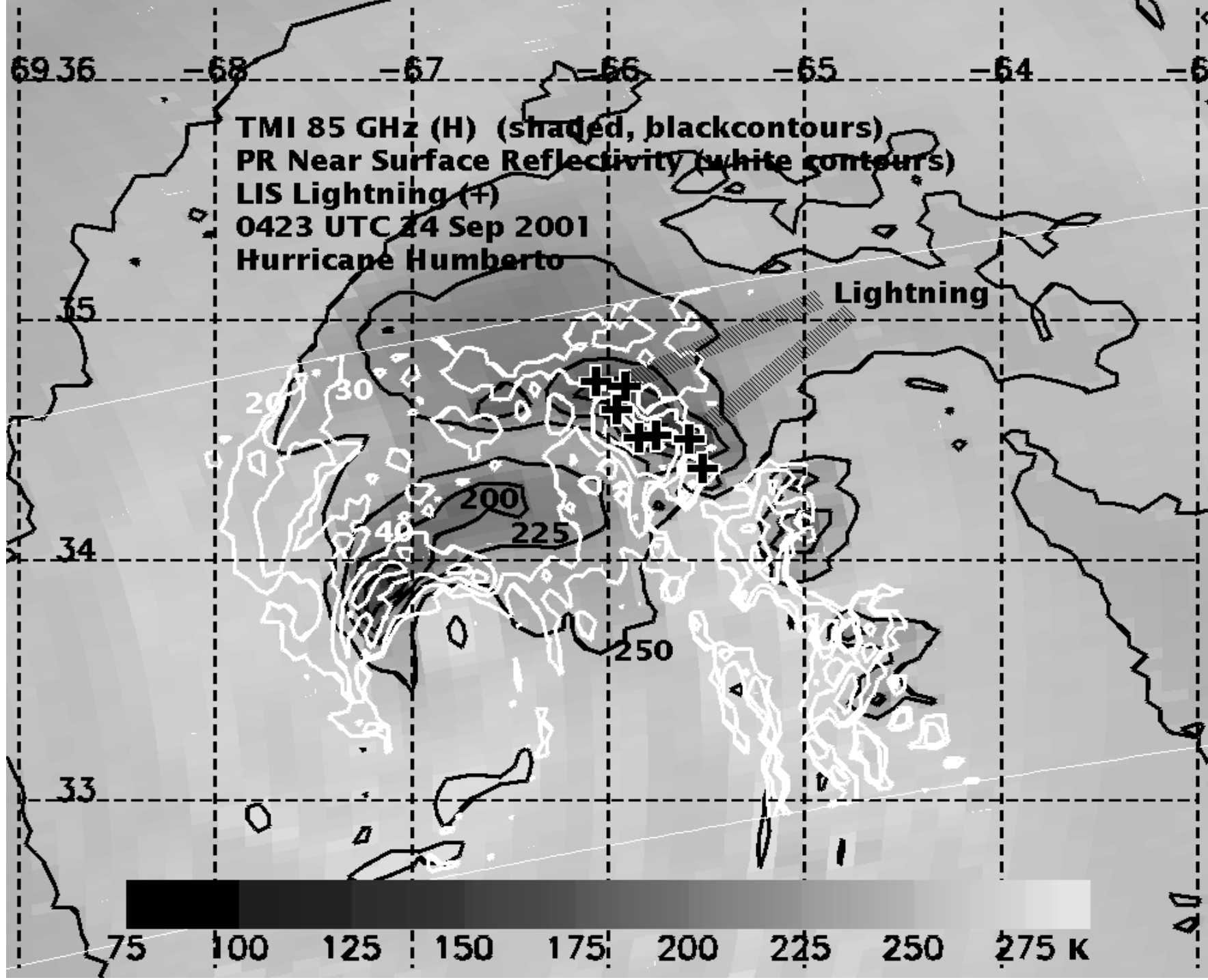


37.1



85.5





The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "KAMP pass 1 of 8"

19 Sep 2001 (262) 17:20:12-17:25:17 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

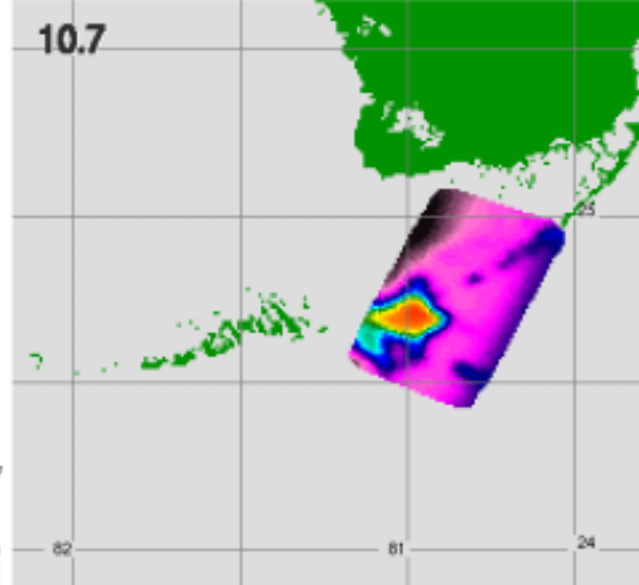


NASA ER-2 Flight Track

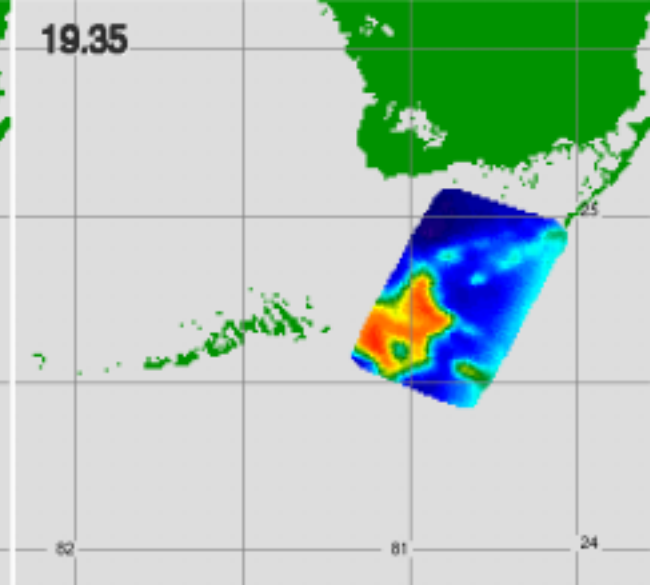
Mean Altitude: 20381 m



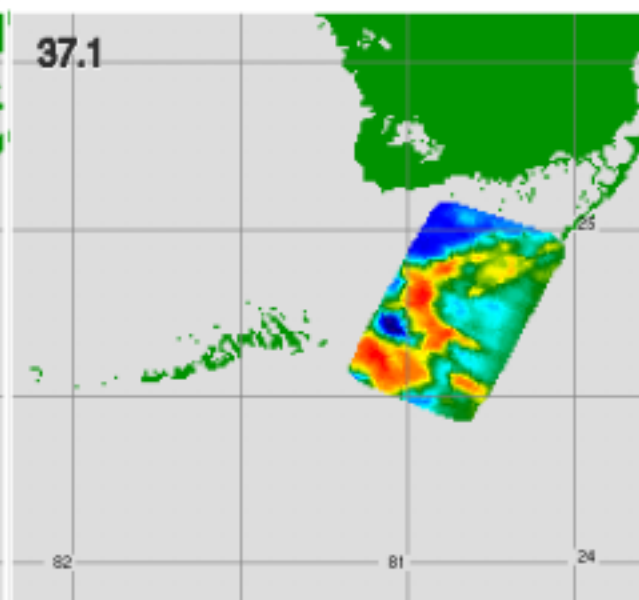
10.7



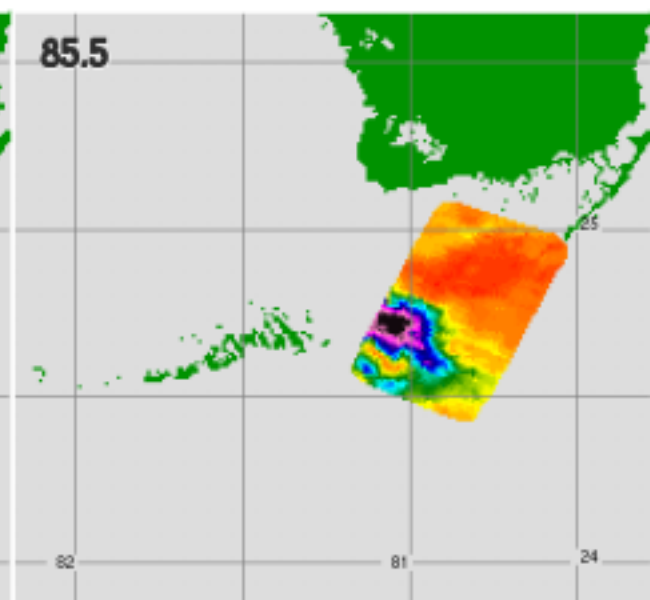
19.35



37.1



85.5



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "KAMP pass 2 of 8"

19 Sep 2001 (262) 17:32:14-17:38:19 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$$

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

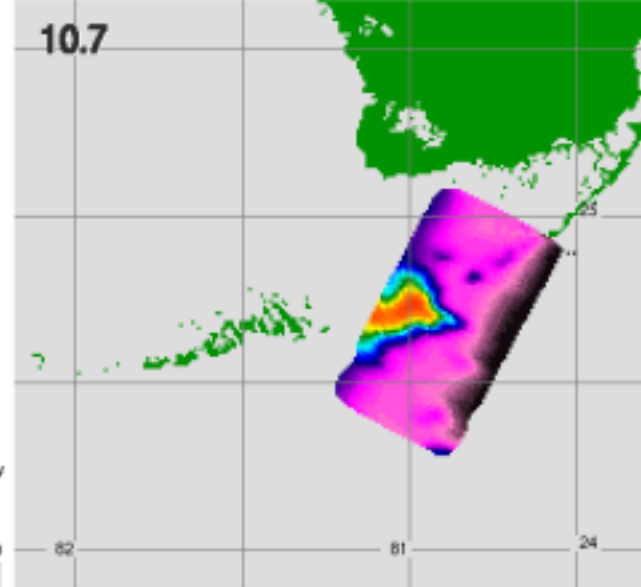


NASA ER-2 Flight Track

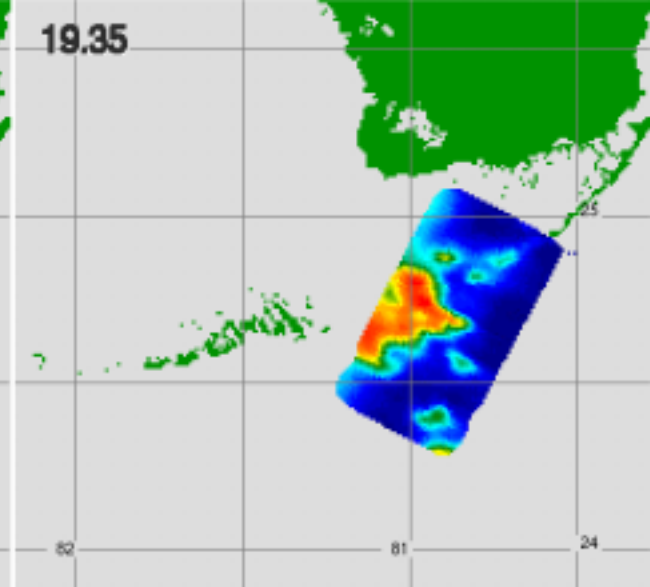
Mean Altitude: 20432 m



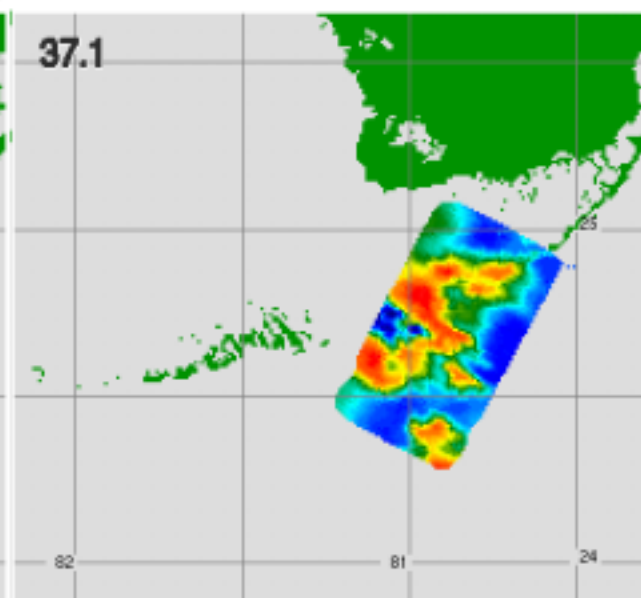
10.7



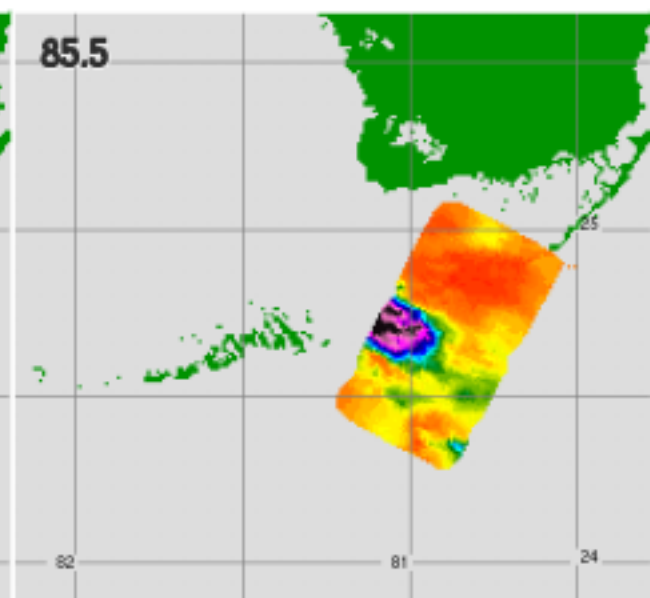
19.35



37.1



85.5



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "KAMP pass 3 of 8"

19 Sep 2001 (262) 17:55:45-18:01:20 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$$

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

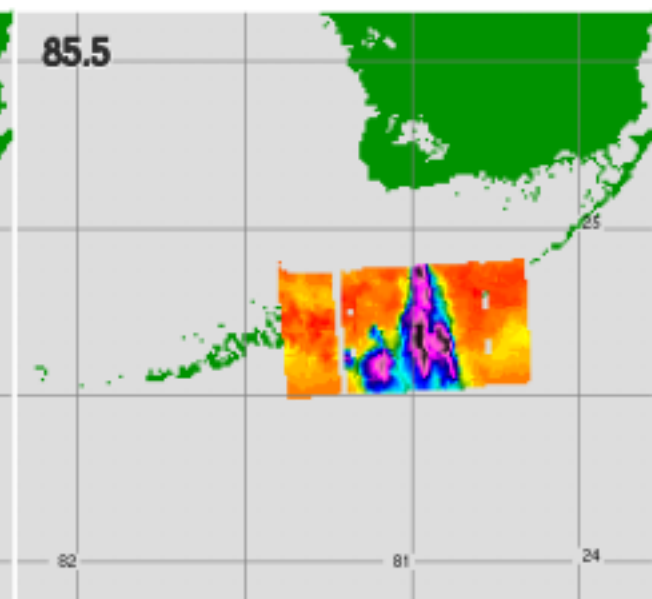
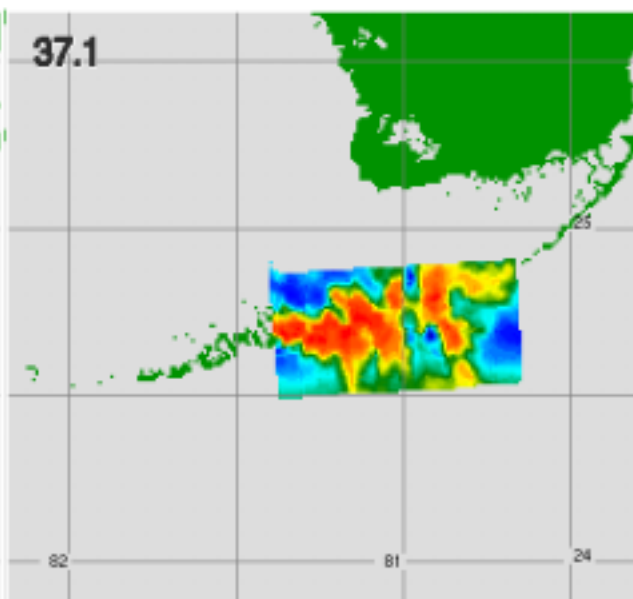
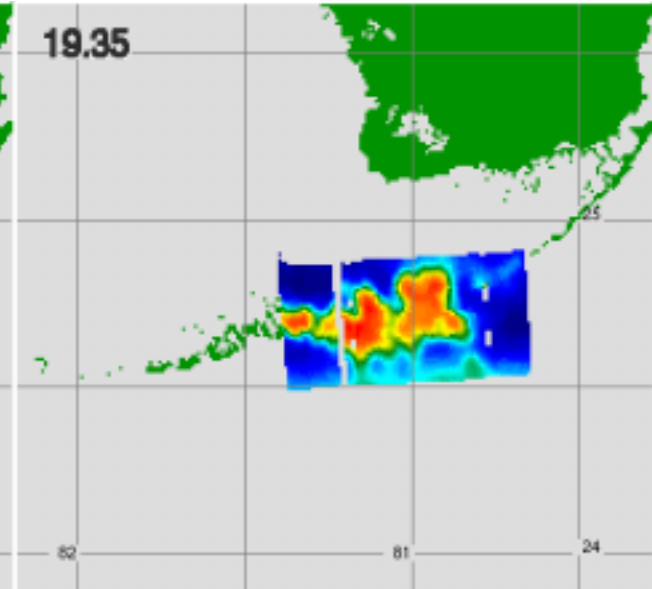
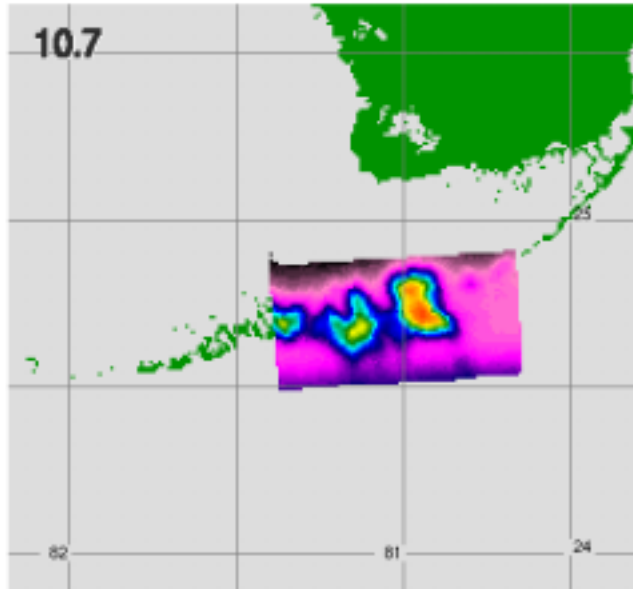
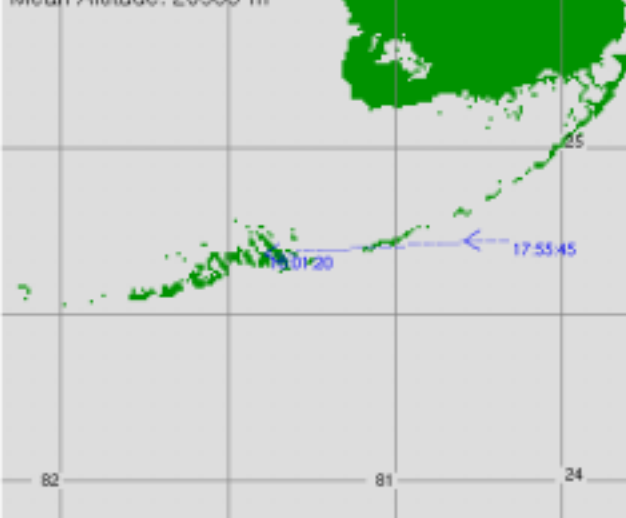
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300



NASA ER-2 Flight Track

Mean Altitude: 20586 m



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "KAMP pass 4 of 8"

19 Sep 2001 (262) 18:08:26-18:16:11 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$$

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

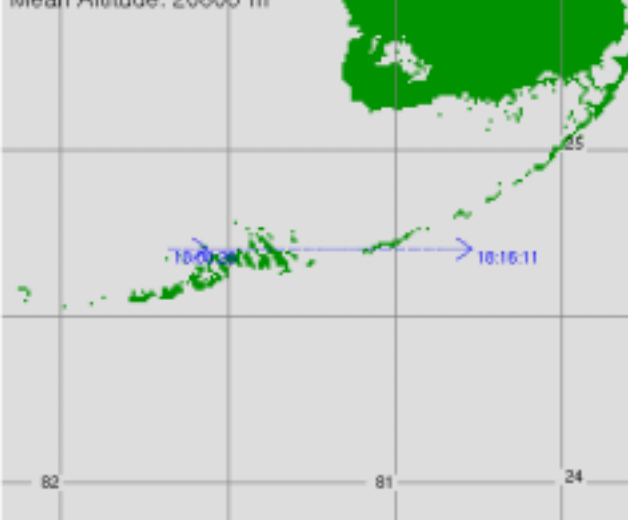
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

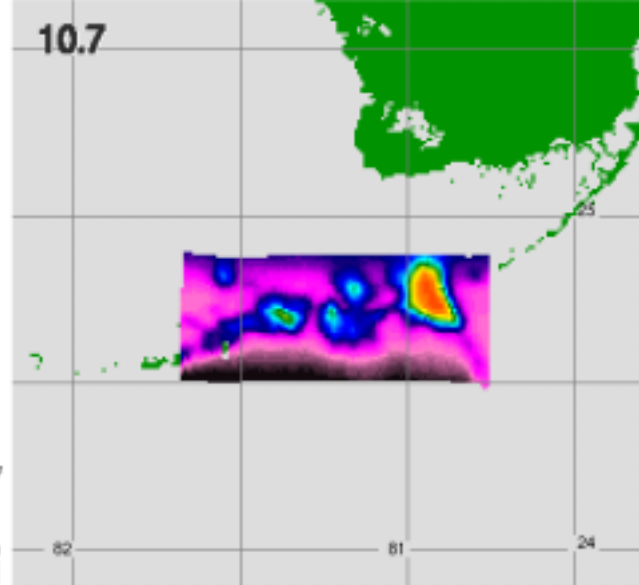


NASA ER-2 Flight Track

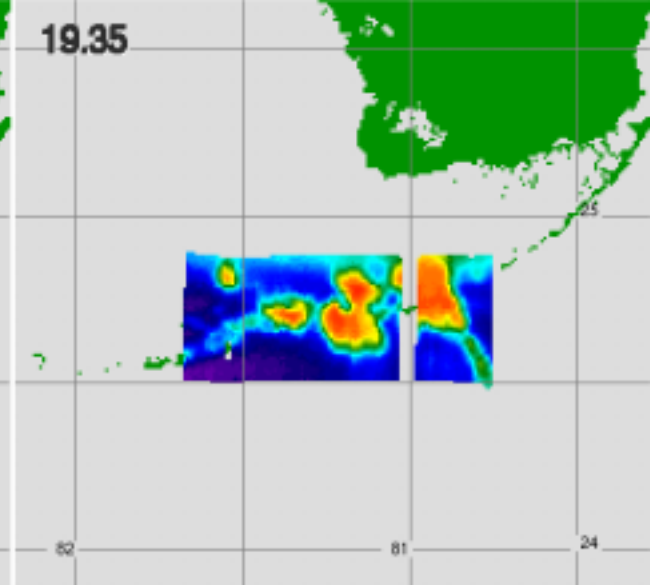
Mean Altitude: 20806 m



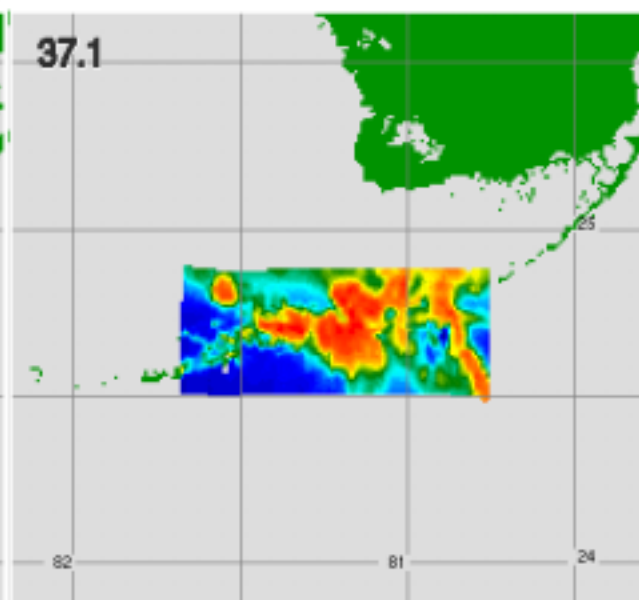
10.7



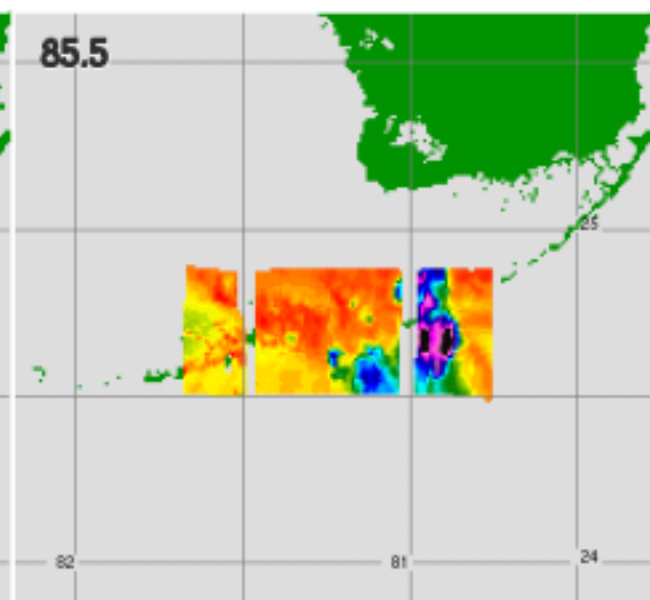
19.35



37.1



85.5



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "KAMP pass 5 of 8"

19 Sep 2001 (262) 18:24:51-18:31:33 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$$

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

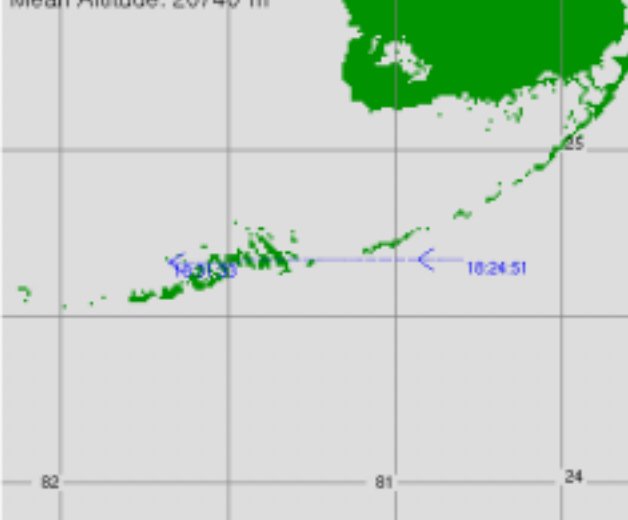
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

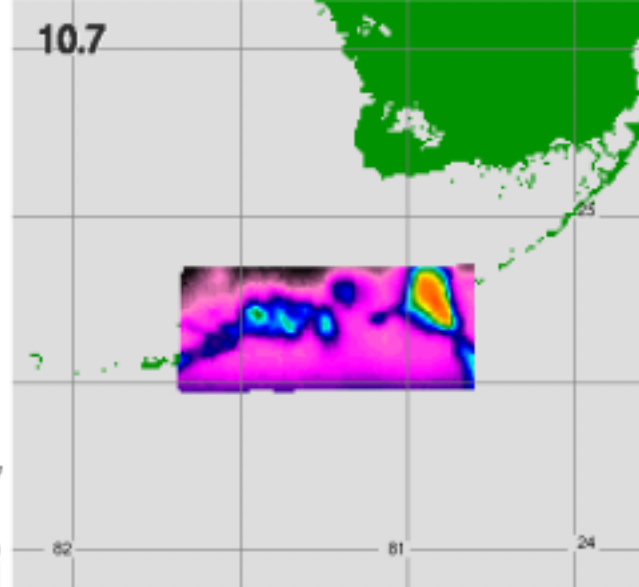


NASA ER-2 Flight Track

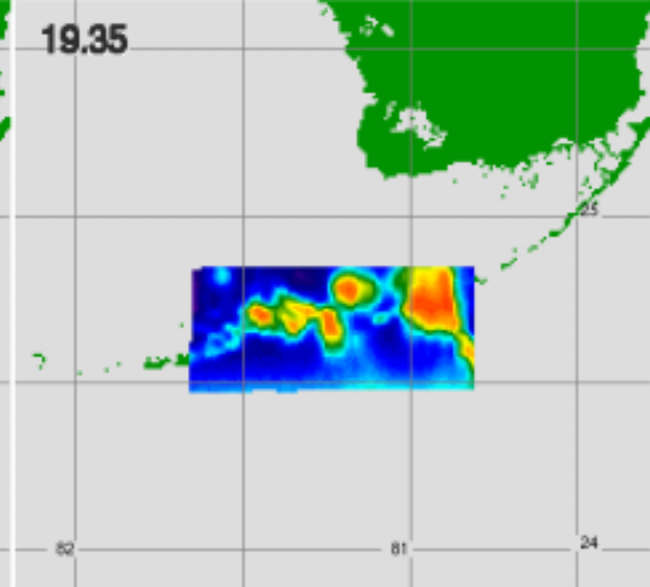
Mean Altitude: 20740 m



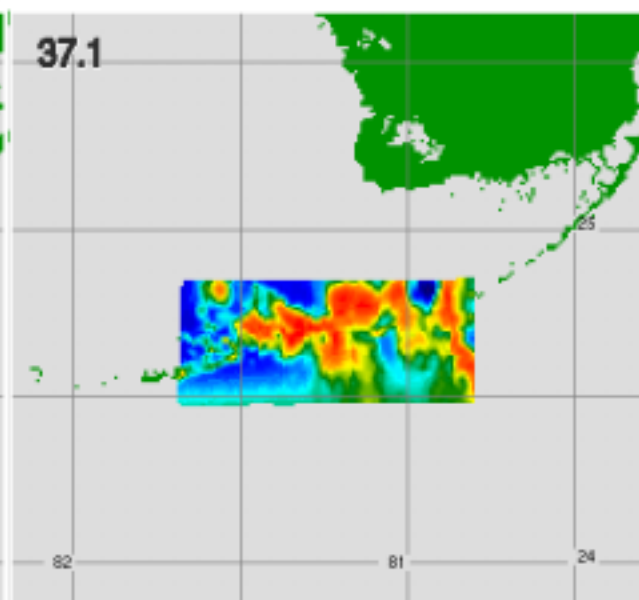
10.7



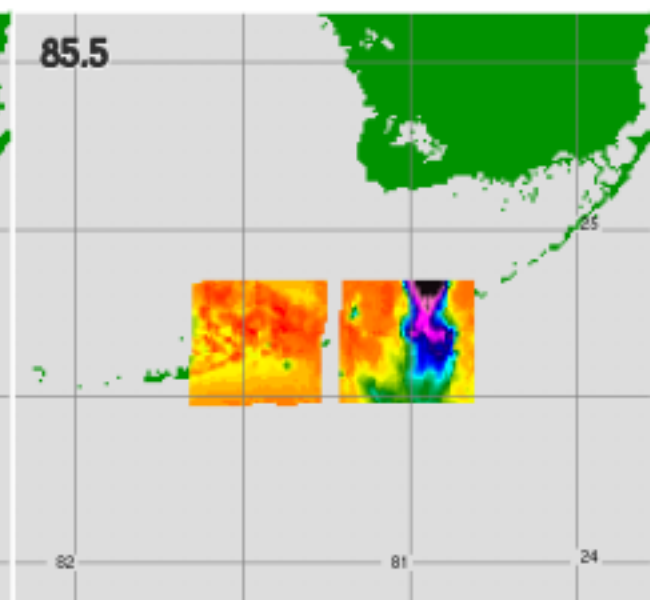
19.35



37.1



85.5



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "KAMP pass 6 of 8"

19 Sep 2001 (262) 18:38:14-18:49:16 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$$

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

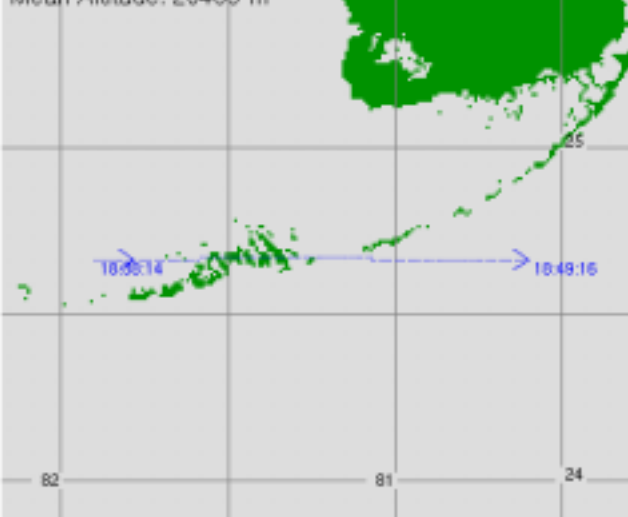
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

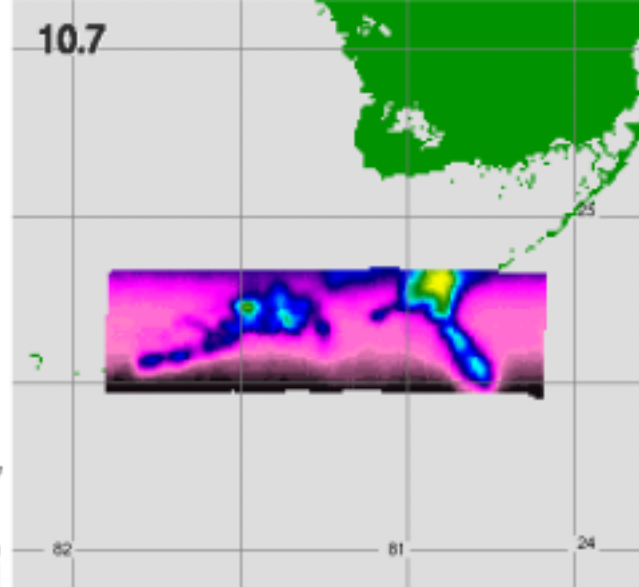


NASA ER-2 Flight Track

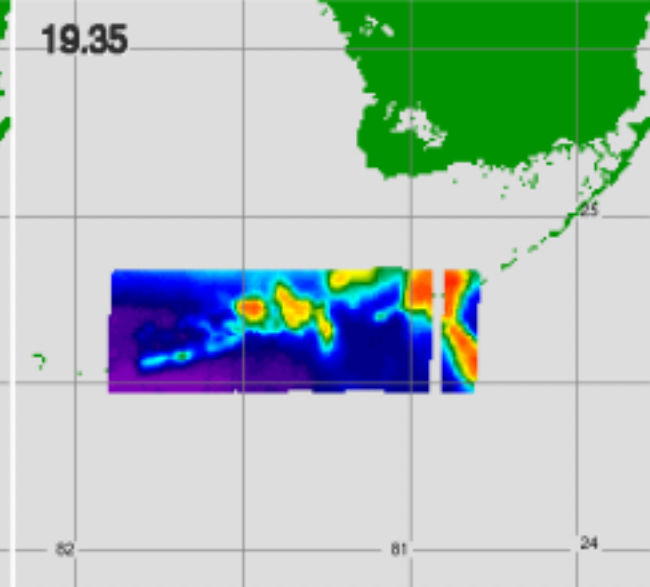
Mean Altitude: 20433 m



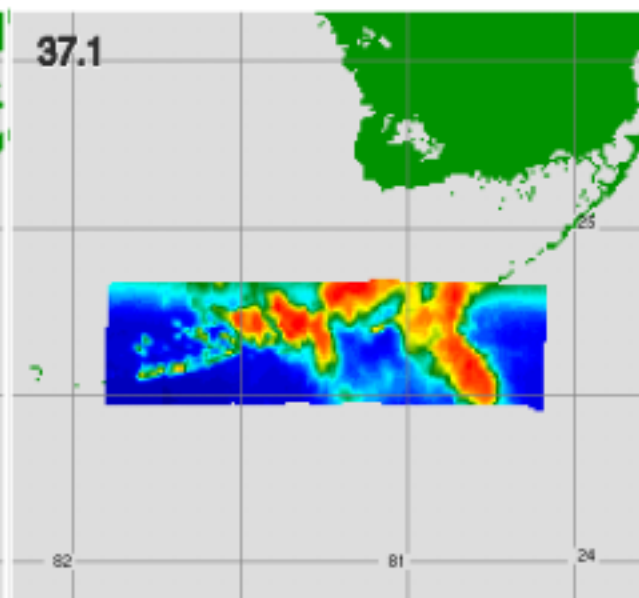
10.7



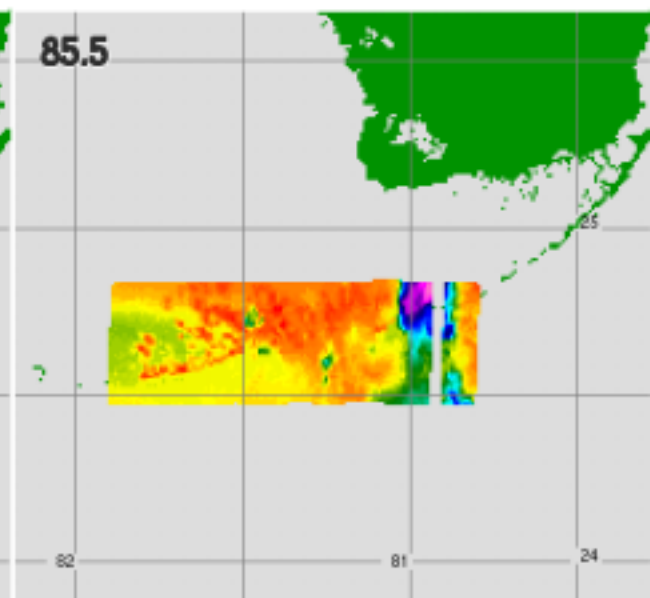
19.35



37.1



85.5



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "KAMP pass 7 of 8"

19 Sep 2001 (262) 18:56:19-19:04:01 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

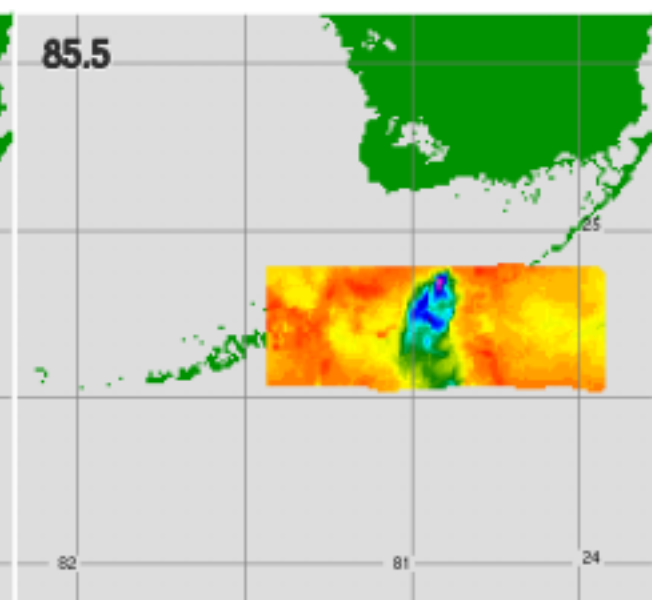
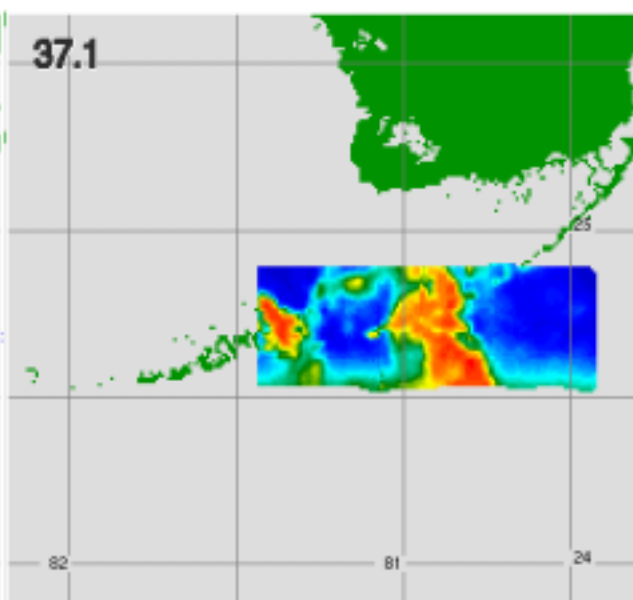
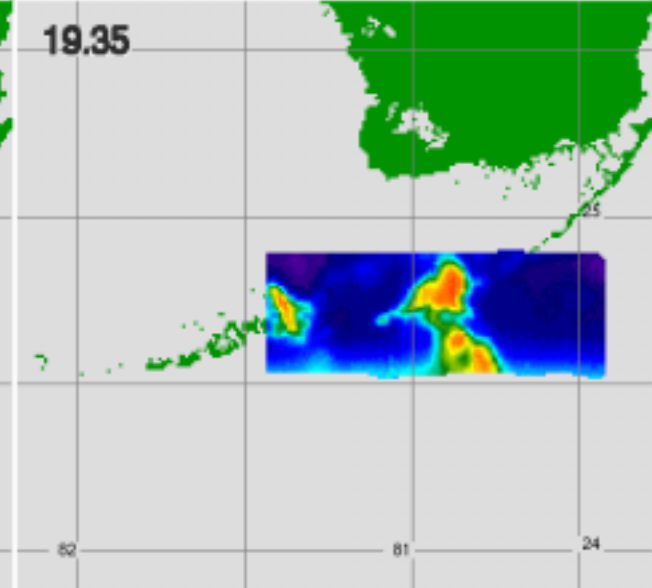
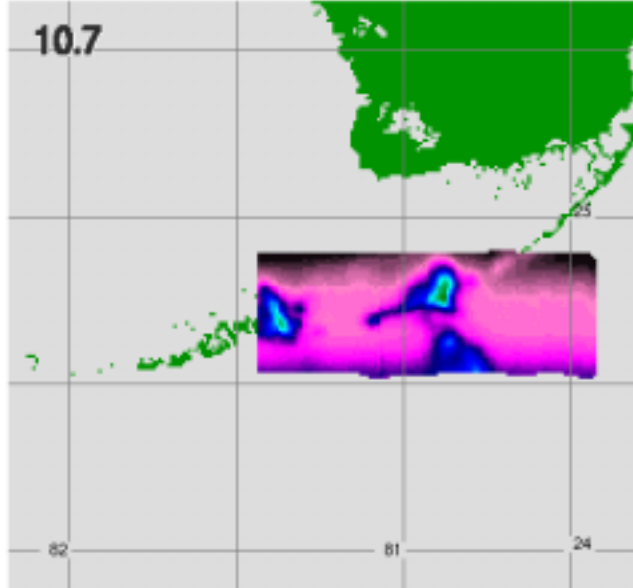
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300



NASA ER-2 Flight Track

Mean Altitude: 20400 m



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "KAMP pass 8 of 8"

19 Sep 2001 (262) 19:17:49–19:24:46 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

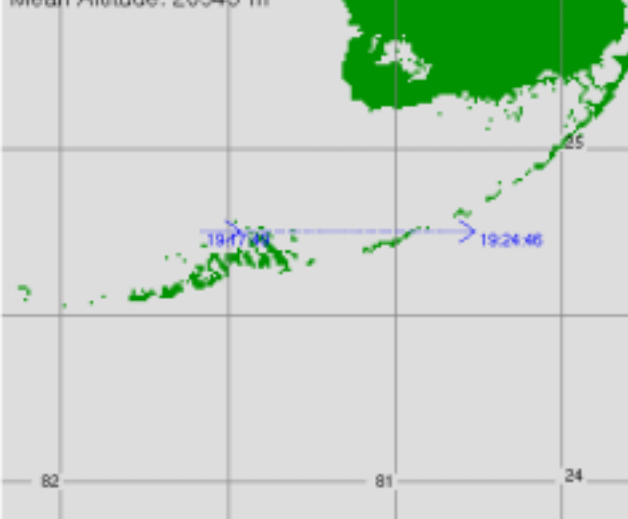
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300

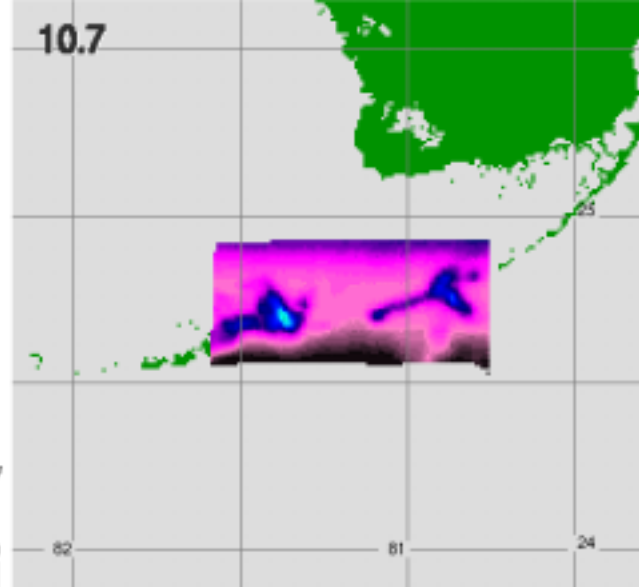


NASA ER-2 Flight Track

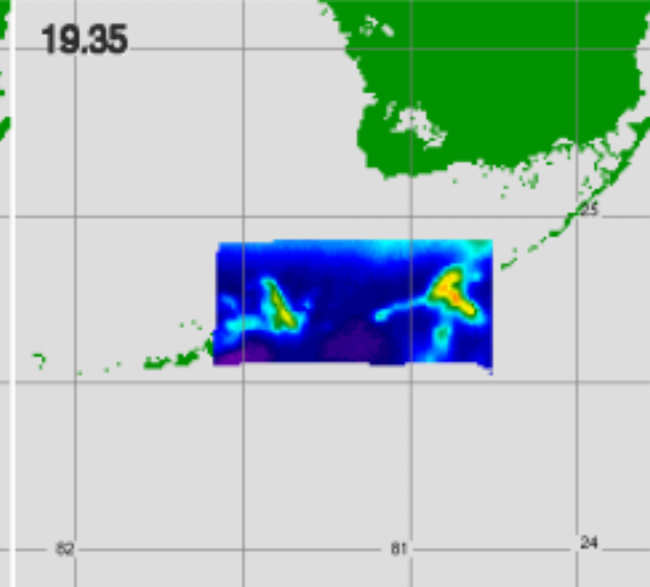
Mean Altitude: 20543 m



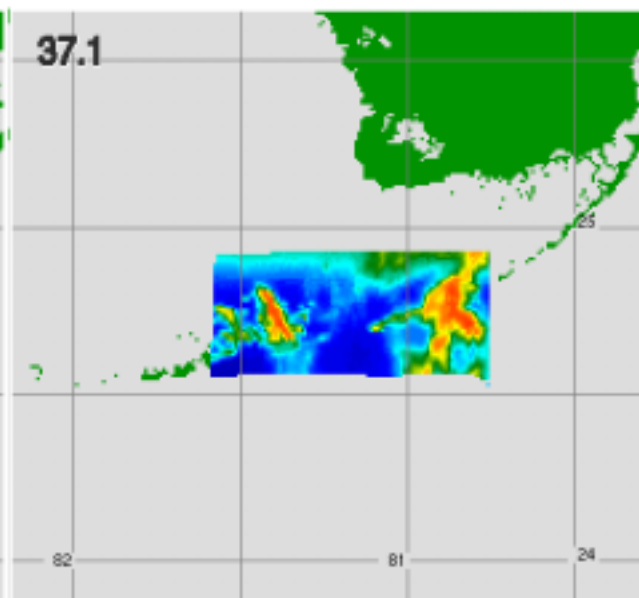
10.7



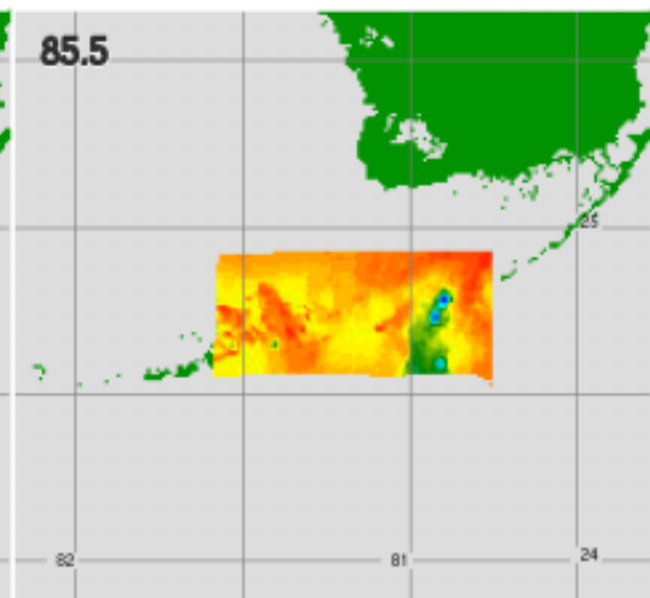
19.35



37.1



85.5



The Advanced Microwave Precipitation Radiometer (AMPR)

Image from CAMEX-4 "KAMP (transit)"

19 Sep 2001 (262) 20:05:57-20:32:29 UTC

Frequencies in GHz

Cross-Track Scan (L-to-R in direction of motion)

$V[\cos^2(\theta+45^\circ)] + H[\sin^2(\theta+45^\circ)] = 1$

Grid Center: 26.00°N x 81.00°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

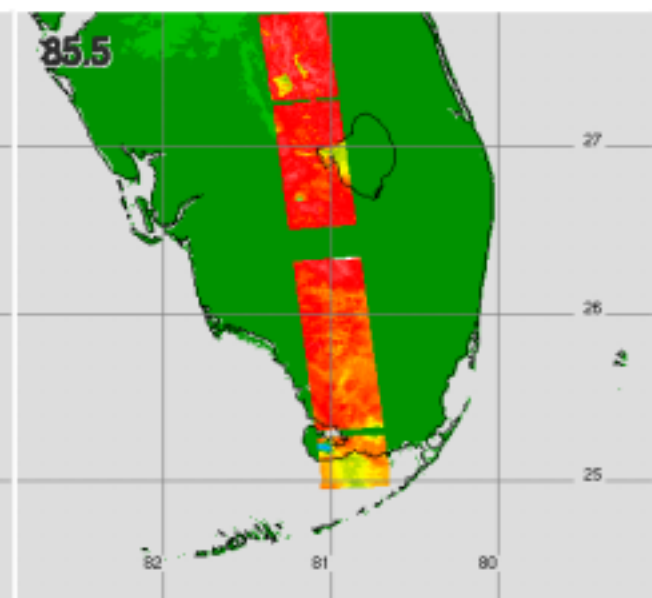
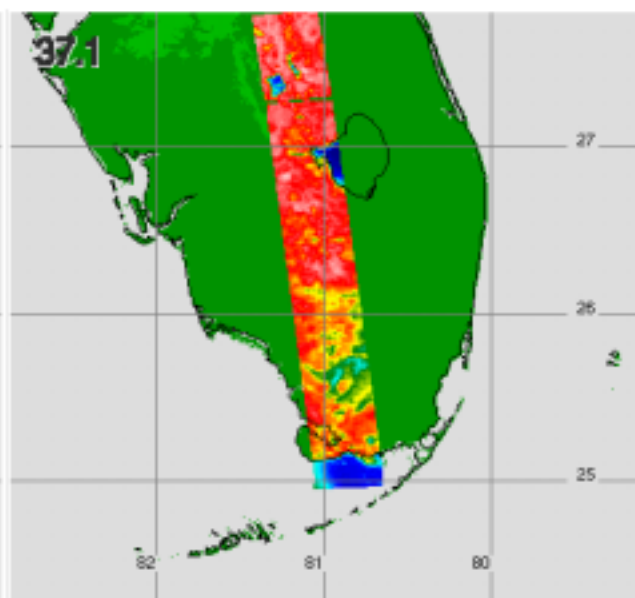
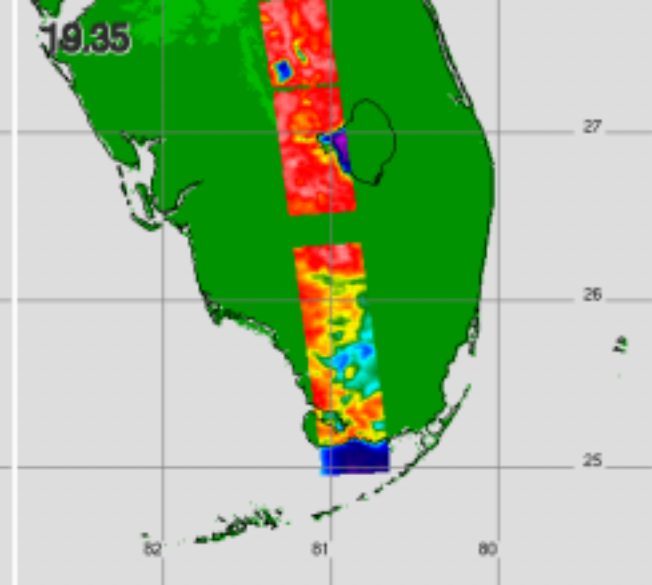
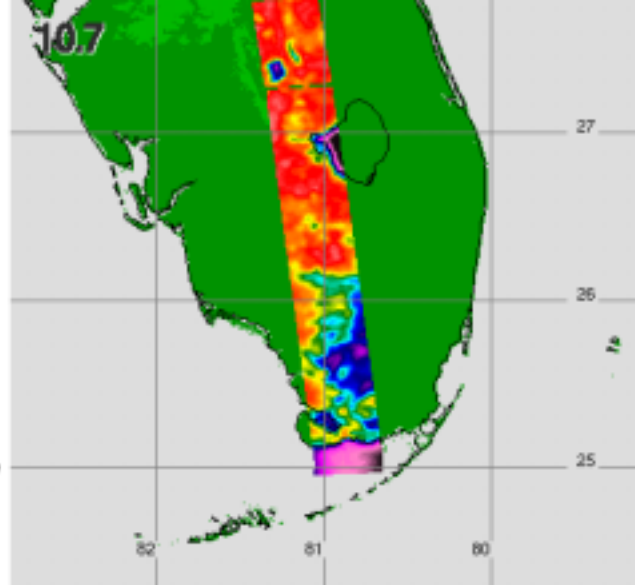
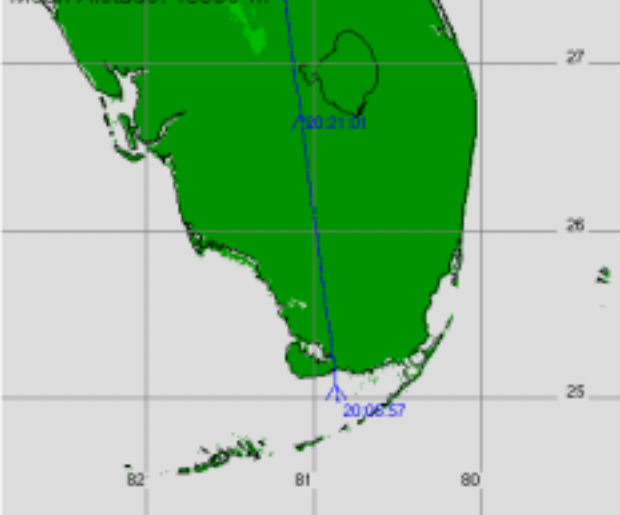
Brightness Temperature in Kelvin

100 120 140 160 180 200 220 240 260 280 300



NASA ER-2 Flight Track

Mean Altitude: 19990 m



The Conical-Scanning Two-look Airborne Radiometer (C-STAR)

Image from CAMEX-4 "Pass 5 (2X)"

19 Sep 2001 (262) 17:58:39-18:04:00 UTC

Frequencies in GHz

Conical Scan (clockwise in direction of motion)

-45° to +45° fore and aft at 53° incidence

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

Brightness Temperature in Kelvin

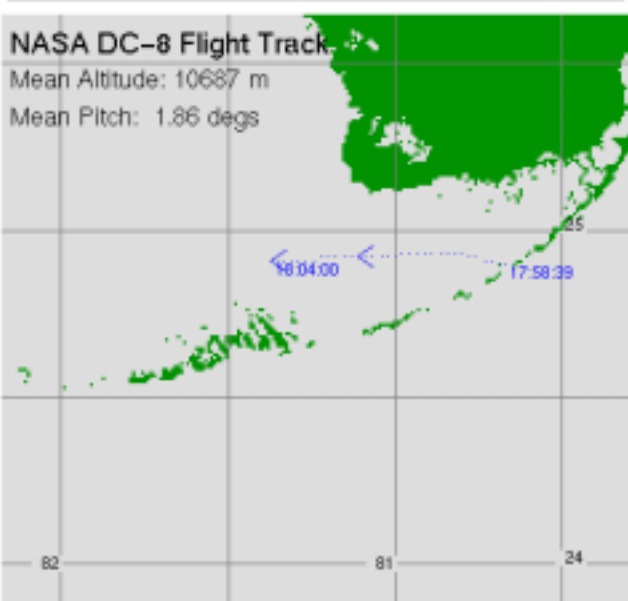
100 120 140 160 180 200 220 240 260 280 300



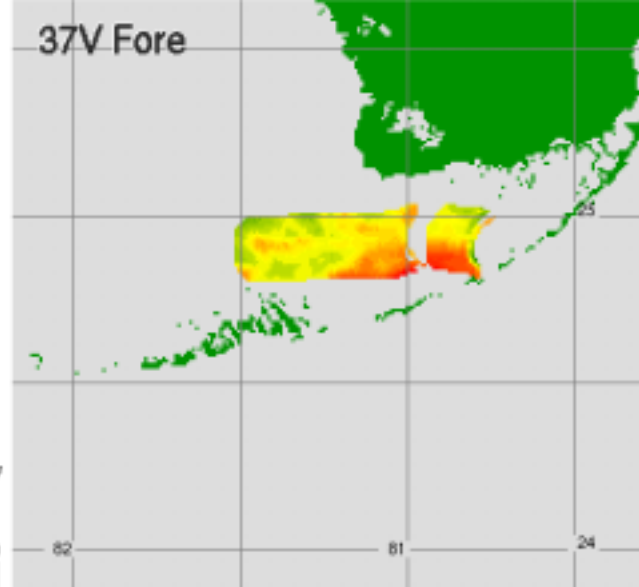
NASA DC-8 Flight Track

Mean Altitude: 10687 m

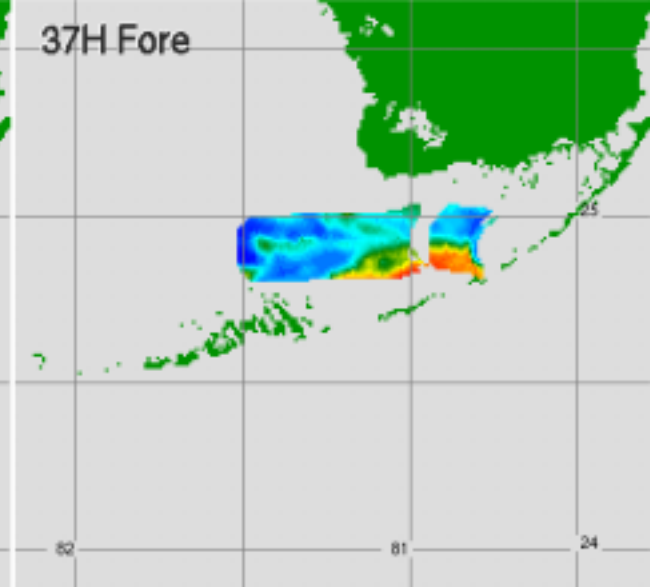
Mean Pitch: 1.86 degs



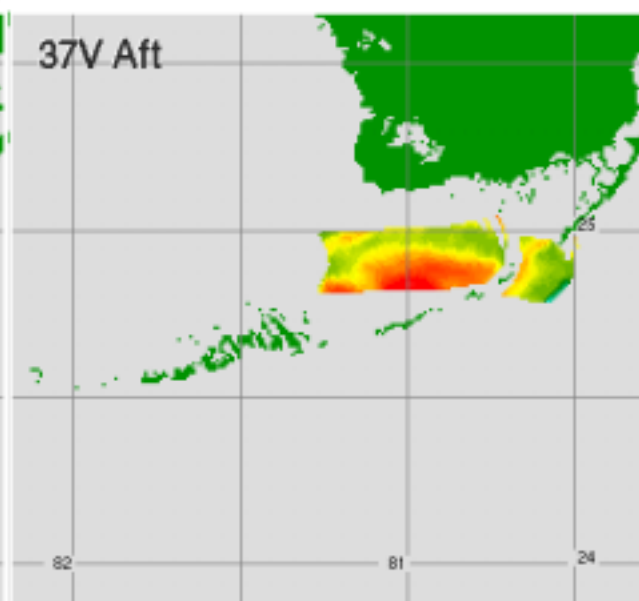
37V Fore



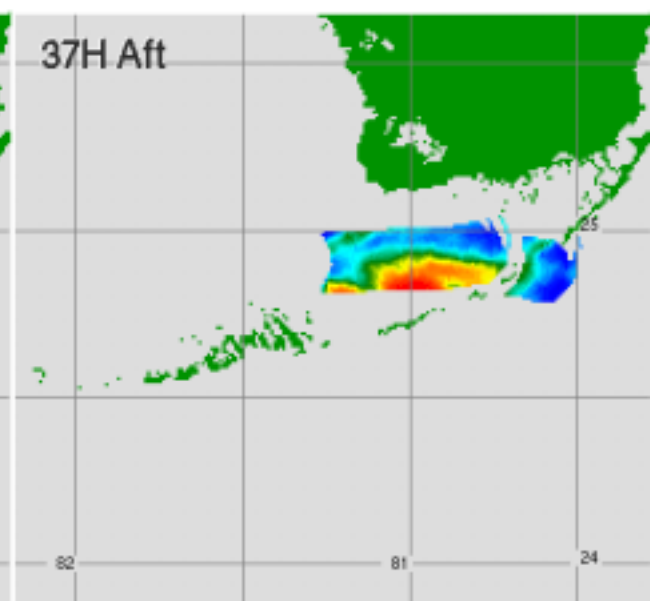
37H Fore



37V Aft



37H Aft



The Conical-Scanning Two-look Airborne Radiometer (C-STAR)

Image from CAMEX-4 "Pass 6 (2X)"

19 Sep 2001 (262) 18:07:21-18:12:32 UTC

Frequencies in GHz

Conical Scan (clockwise in direction of motion)

-45° to +45° fore and aft at 53° incidence

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

Brightness Temperature in Kelvin

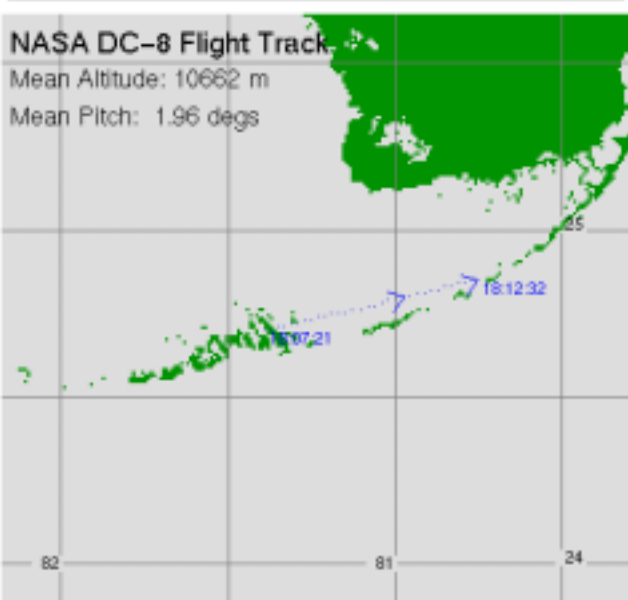
100 120 140 160 180 200 220 240 260 280 300



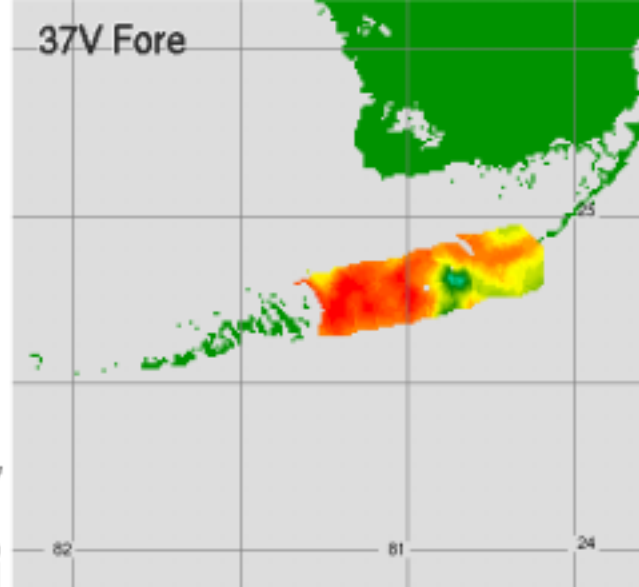
NASA DC-8 Flight Track

Mean Altitude: 10662 m

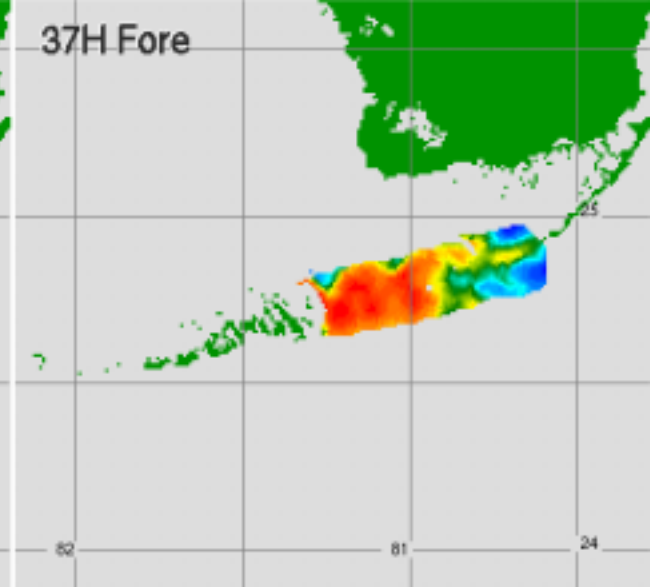
Mean Pitch: 1.96 degs



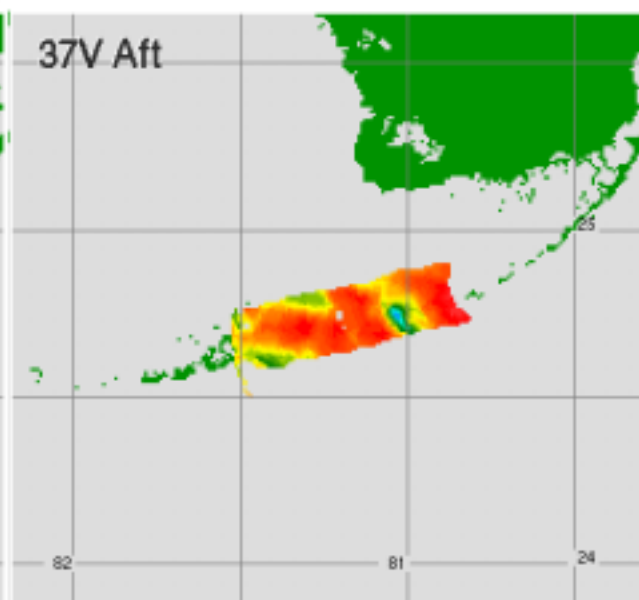
37V Fore



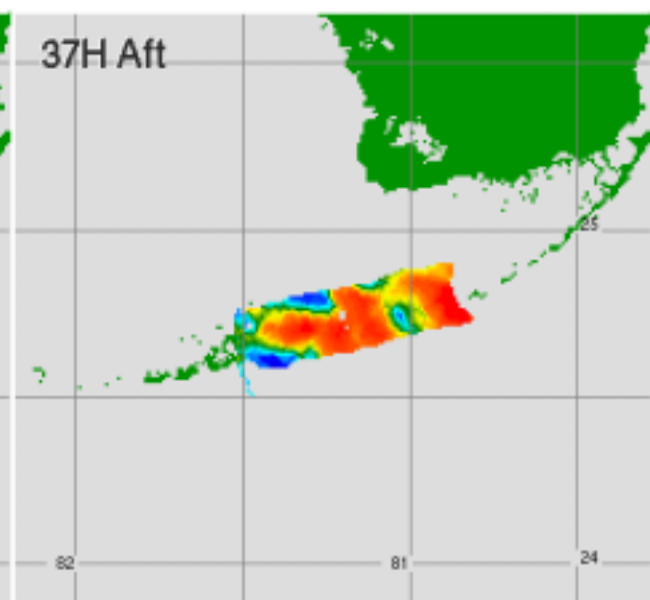
37H Fore



37V Aft



37H Aft



The Conical-Scanning Two-look Airborne Radiometer (C-STAR)

Image from CAMEX-4 "Pass 7 (2X)"

19 Sep 2001 (262) 18:30:46-18:39:08 UTC

Frequencies in GHz

Conical Scan (clockwise in direction of motion)

-45° to +45° fore and aft at 53° incidence

Grid Center: 24.75°N x 81.25°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

Brightness Temperature in Kelvin

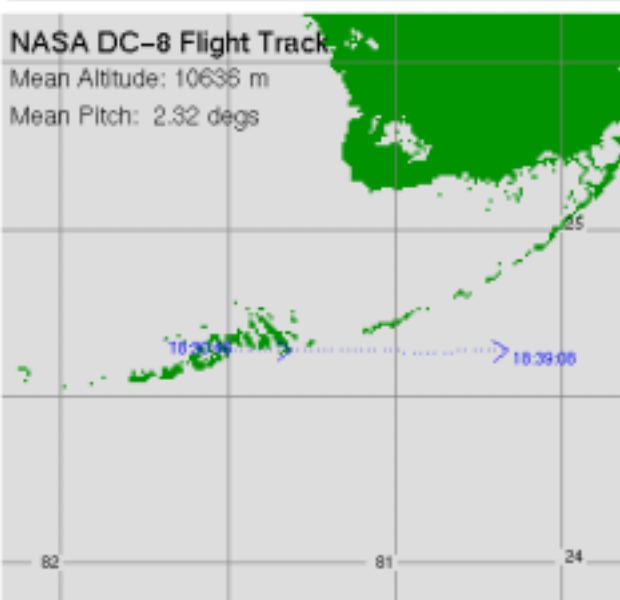
100 120 140 160 180 200 220 240 260 280 300



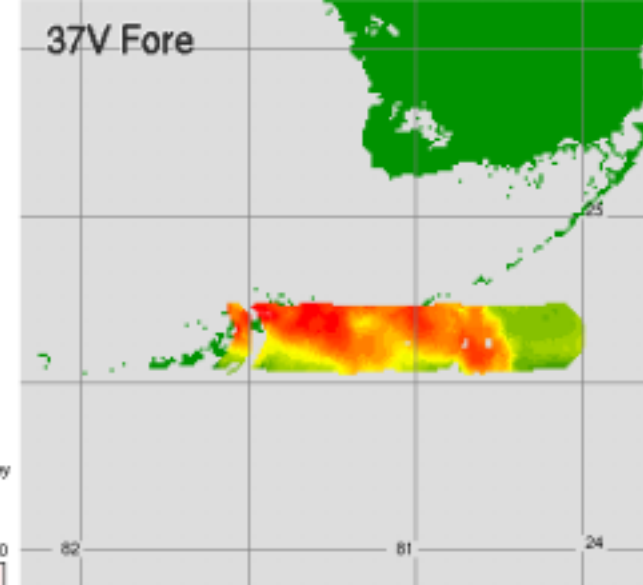
NASA DC-8 Flight Track

Mean Altitude: 10636 m

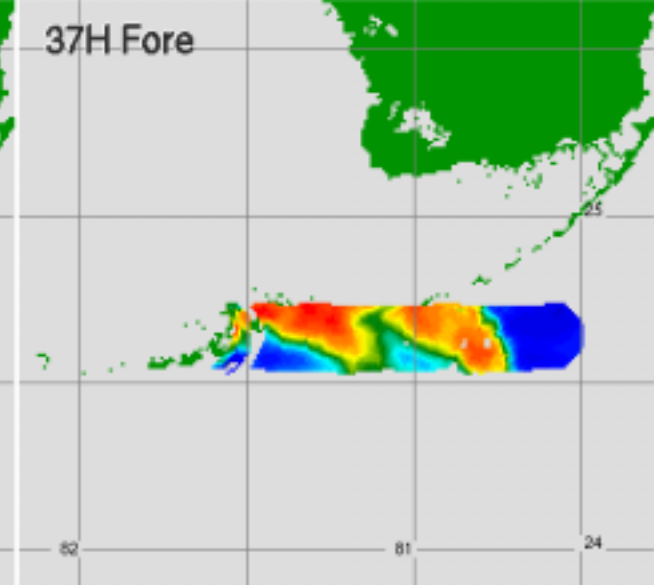
Mean Pitch: 2.32 degs



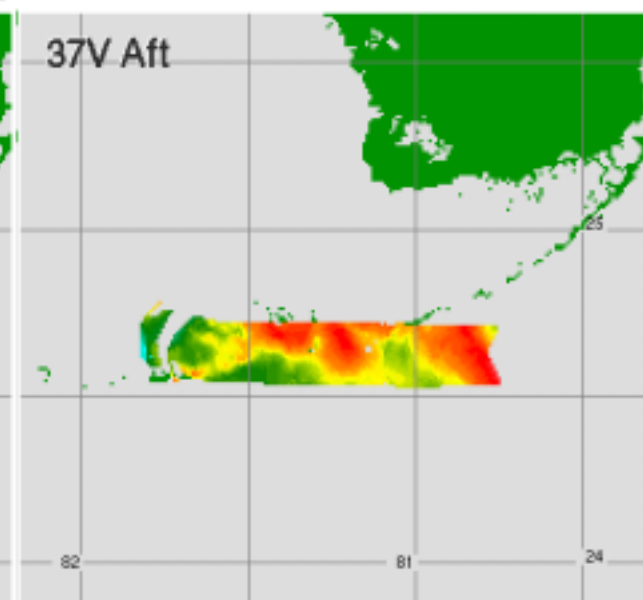
37V Fore



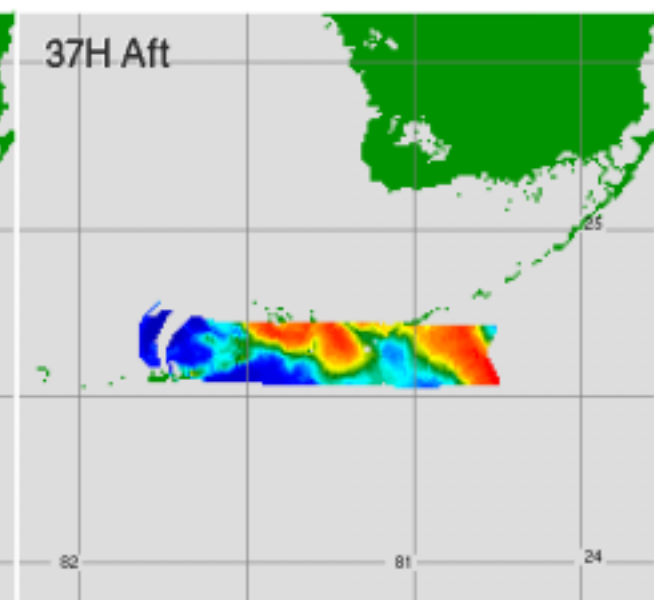
37H Fore

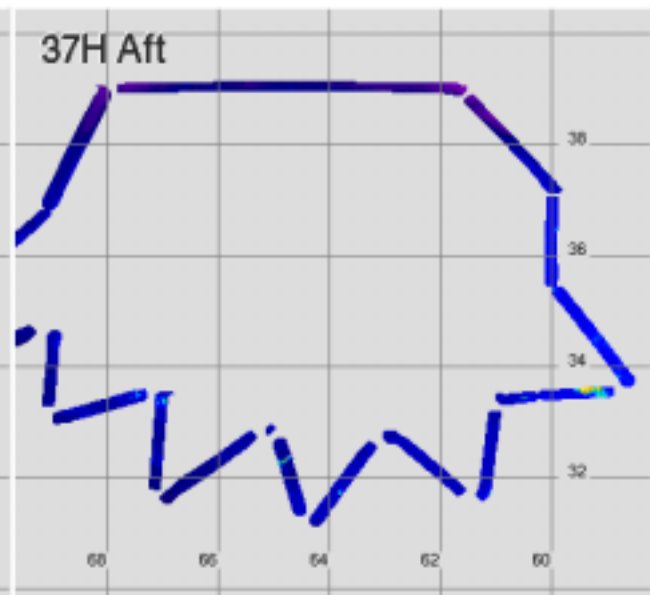
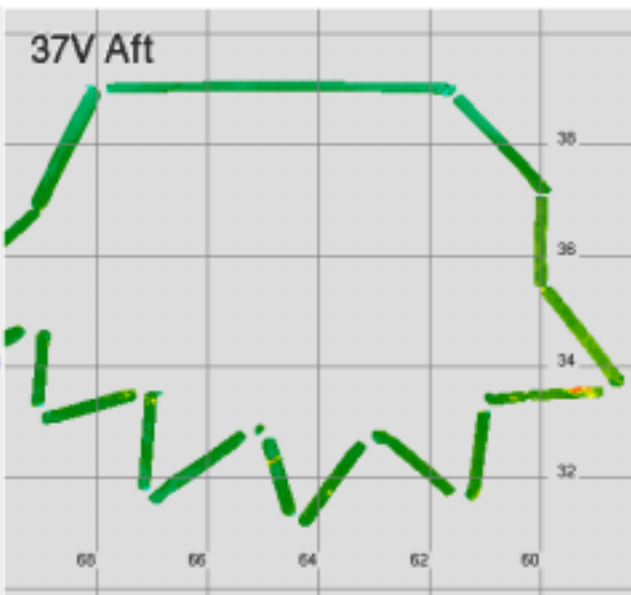
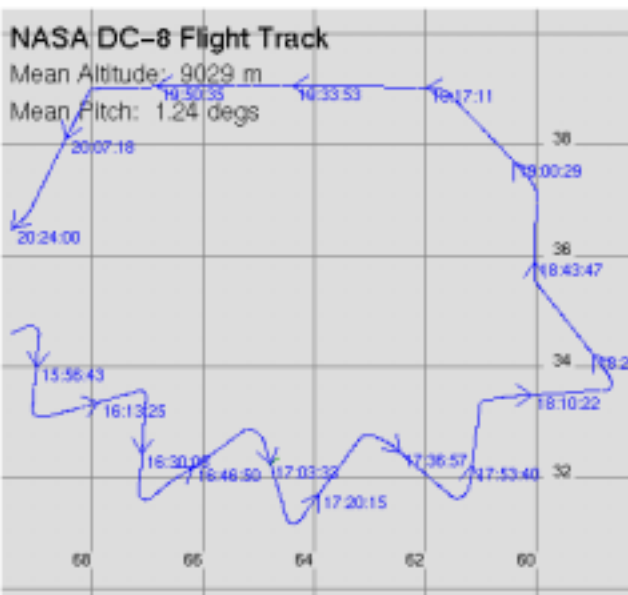
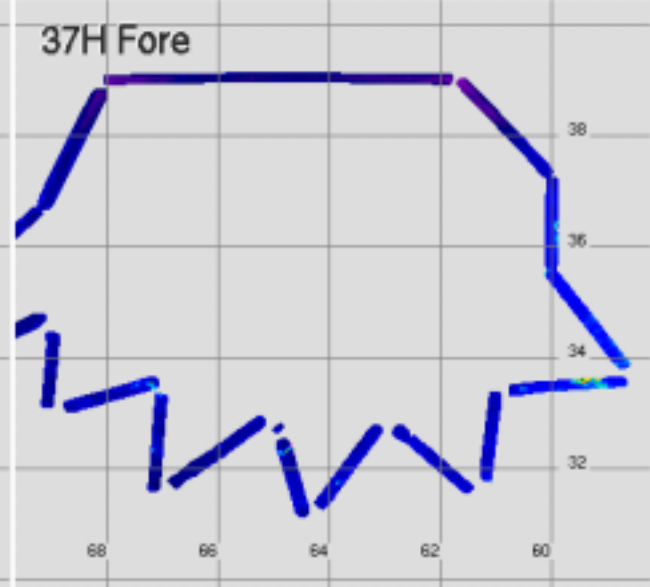
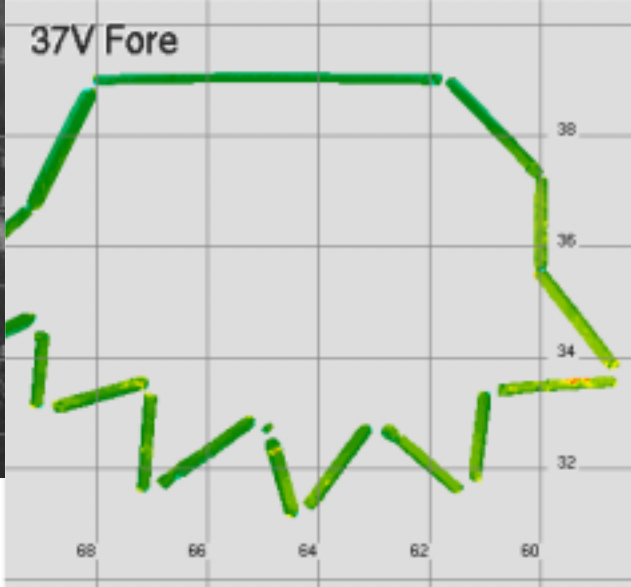
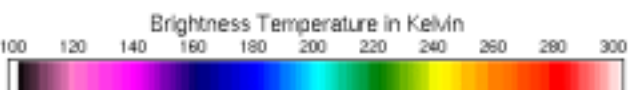
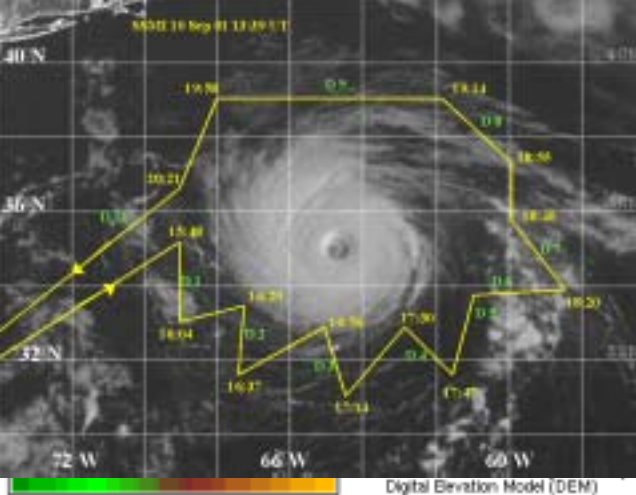


37V Aft



37H Aft





The Conical-Scanning Two-look Airborne Radiometer (C-STAR)

Image from CAMEX-4 Erin (Leg 9)

10 Sep 2001 (253) 18:23:34-18:40:06 UTC

Frequencies in GHz

Conical Scan (clockwise in direction of motion)

-45° to +45° fore and aft at 53° incidence

Grid Center: 34.67°N x 59.34°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

Brightness Temperature in Kelvin

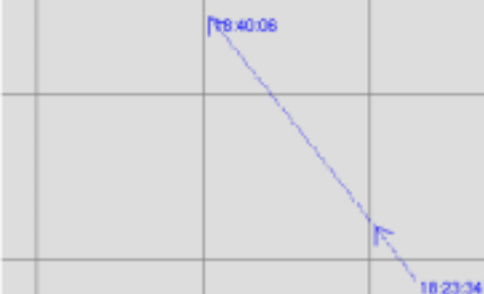
100 120 140 160 180 200 220 240 260 280 300



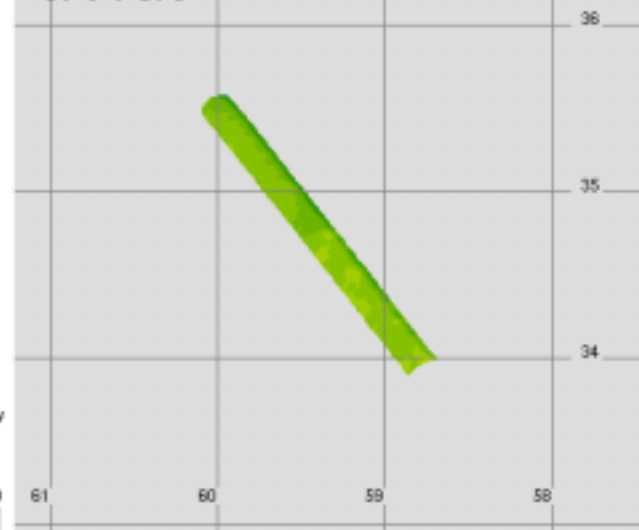
NASA DC-8 Flight Track

Mean Altitude: 9058 m

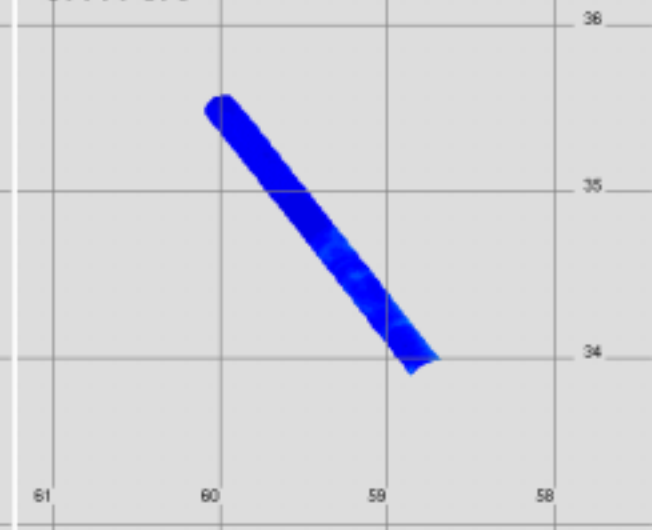
Mean Pitch: 1.60 degs



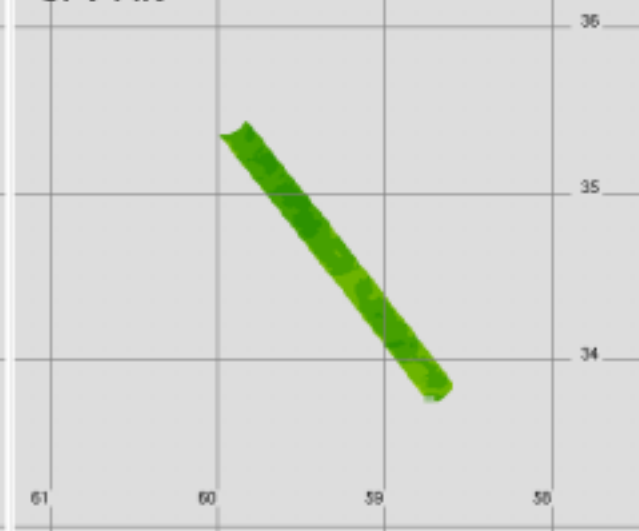
37V Fore



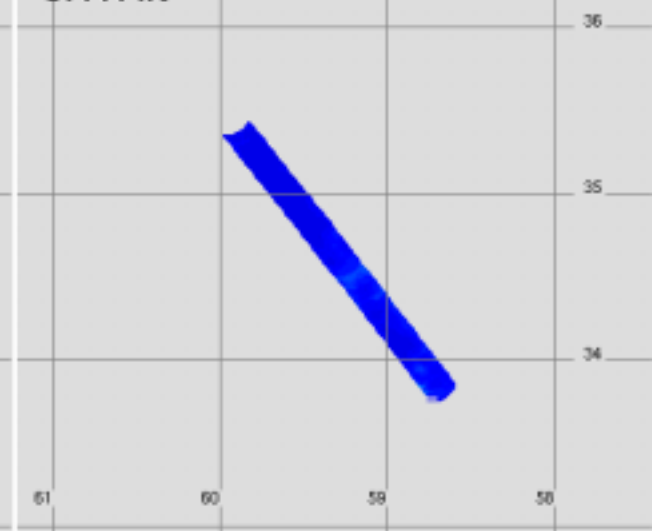
37H Fore



37V Aft



37H Aft



The Conical-Scanning Two-look Airborne Radiometer (C-STAR)

Image from CAMEX-4 Erin (Leg 10)

10 Sep 2001 (253) 18:41:06-18:54:48 UTC

Frequencies in GHz

Conical Scan (clockwise in direction of motion)

-45° to +45° fore and aft at 53° incidence

Grid Center: 36.35°N x 60.01°W

Grid Resolution: 1.00 km

NASA/NSSTC/GHCC Version 1.0

Some data may have been interpolated

Elevation in Meters

0 250 500

Source: United States Geological Survey
Digital Elevation Model (DEM)

Brightness Temperature in Kelvin

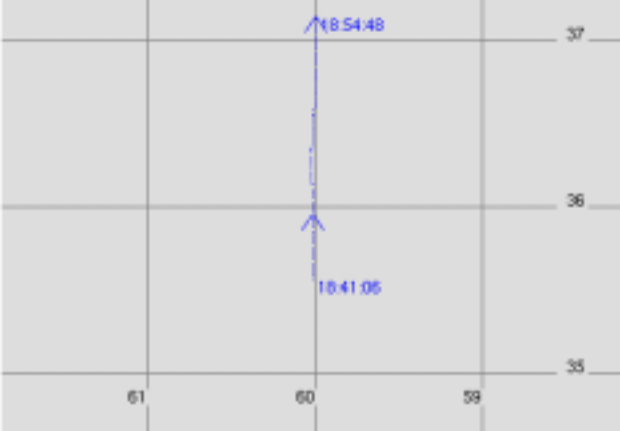
100 120 140 160 180 200 220 240 260 280 300



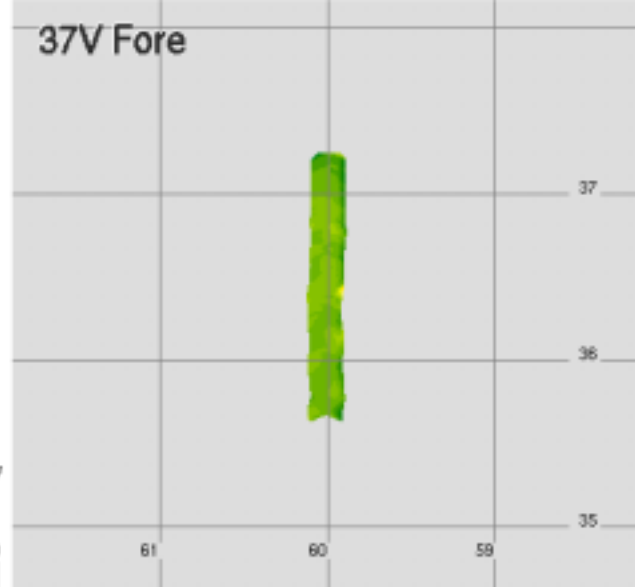
NASA DC-8 Flight Track

Mean Altitude: 9059 m

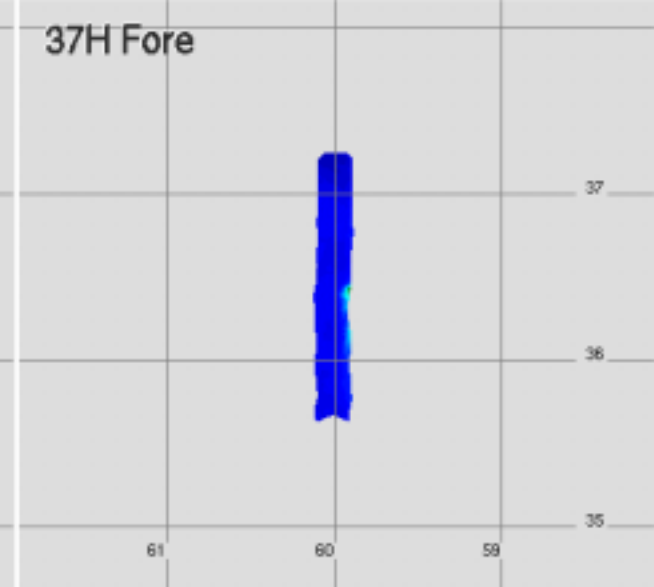
Mean Pitch: 1.54 degs



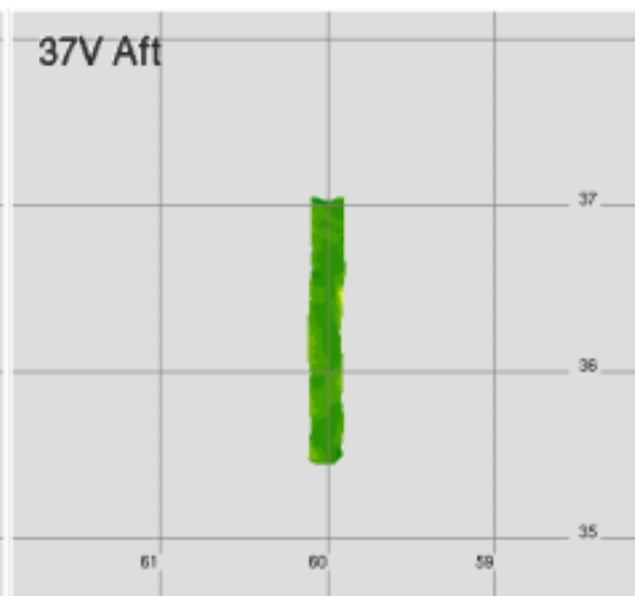
37V Fore



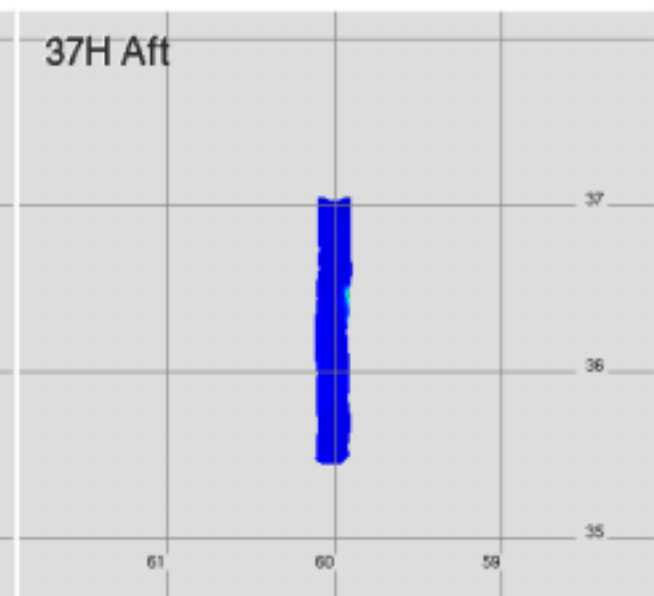
37H Fore



37V Aft



37H Aft



Collaborations

- Study relationship of active and passive microwave signatures with lightning as an indicators of storm intensity changes
 - Current partners: Hood, LaFontaine, Cecil, Guillory, Marks, Gerry Heymsfield, Ed Zipser, and Rich Blakeslee
- Studying potential of high spatial resolution passive microwave instrumentation to monitor inland flooding
 - Current partners: Hood, LaFontaine, Cecil, Guillory, and Marks
- Investigate feasibility passive microwave ocean wind retrievals
 - Planned partners: Hood, LaFontaine, Cecil, Guillory, and Linwood Jones